THE FUTURE IN PRACTICE

THE STATE OF SUSTAINABILITY LEADERSHIP

UNIVERSITY OF CAMBRIDGE
PROGRAMME FOR SUSTAINABILITY LEADERSHIP
25 YEARS

The State of Sustainability Leadership is the annual collection of ideas and research from the University of Cambridge Programme for Sustainability Leadership (CPSL), exploring how business and policy leaders are tackling the challenges of the 21st century.

This year's edition focuses on leadership for the long term, asking: how can executives think far-sightedly, and interpret their responsibilities towards future generations, to build a more sustainable world?

With expert contributions from CPSL's worldwide network of business leaders, policymakers and academics, this report teases out what we can expect of sustainability and business in the future, as well as highlighting progress towards factoring this foreseeable future into business decisions today.

COVER IMAGE
In Chris Wainwright's series *Red Ice / White Ice* (2009), floating icebergs were photographed under lights to give the impression of heat surrounded by the blackness of the Arctic night. The artist risked the unpredictable calving and rolling of enormous icebergs as he made his way through the waters. He had to get close enough to these mountains of ice to illuminate them with the light of the projector, exploring both the fragility and awesome power of the ice.

This publication has been developed by and is released by CPSL, 1 Trumpington Street, Cambridge CB2 1QA, UK. Email: info@cpsl.cam.ac.uk

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Leonid Tishkov's exhibition *Arctic Diary* – an extension of his *Private Moon* series – recreates the almost unbelievably beautiful and magical Arctic world.

The critical link:

strategy and sustainability in leadership development

Polly Courtice

Polly Courtice, LVO, is Founder Director of the University of Cambridge Programme for Sustainability Leadership. She is a Non-Executive Director of Jupiter Green Investment Trust and member of a number of corporate sustainability advisory boards.

Successfully embedding sustainability principles into corporate practice ultimately requires those principles to be embedded into leadership and management development processes. Before any of this can happen effectively, they have to be integrated into the vision and strategy of the organisation. So how are leaders developing the insight and understanding to build sustainability into strategy? This article examines some of the ways leaders are doing this and suggests that building the kind of long-term vision that is needed involves a different type of leadership development.

Over the past 25 years, business has shifted its response to sustainability issues from a focus on compliance and reputation management to longer-term risk management and building competitive advantage. Today, with many parts of the world facing issues such as food shortages, severe income disparity, volatility in energy and agriculture prices, and the sobering likelihood that global temperatures are likely to increase by 4ºC,[1] most leaders of multinational companies – 93% of CEOs, according to an Accenture study[2] – recognise that sustainability issues should be fully integrated into their strategy. Partly, this reflects a shift in perception about value creation. Many top executives, according to a recent McKinsey study, believe that sustainability programmes enhance their companies' short- and long-term value through improved brand reputation, cost savings from resource efficiency, and revenue generation potential from new markets and products.[3] Yet the research also finds that very few companies are leveraging the sustainability of existing products to find new growth or committing R&D resources to bring sustainable products to market.

72% of senior executives surveyed on CPSL's leadership programmes (already a self-selected audience) believe that sustainability is strongly or quite strongly embedded in the awareness of senior leaders, but only 42% agree that sustainability is to any meaningful extent embedded into existing strategies, plans and processes.[4]

Against a global backdrop of ever-increasing complexity and uncertainty, with continuing market turmoil, a focus on conventional economic growth, and pervasive national, regional and international policy gridlock on climate and carbon, many company leaders feel constrained in taking a longer-term view.

Integrating sustainability into corporate strategy and practice is still rather slow and piecemeal for most companies. There are many reasons for this, not least the genuine need for short-term stewardship and the not inconsiderable challenge of defining the long term and building it into present-day operations. Perhaps more important is that the market does not yet consistently reward companies that do attempt to invest in creating more long-term, equitable and sustainable growth.

A challenging context

Very few public companies can report that their efforts in sustainability positively impact their share price. Current ownership and investment structures inexorably drive the focus on short-term results; traditional valuation methodologies like discounted cash flow do not adequately incorporate uncertain future market or policy conditions (a conclusion supported by our work with the Banking and Environment Initiative – BEI – and Cambridge's Judge Business School on assessing clean energy investments); there appears to be a lack of real understanding by asset owners of the 'big system' challenges and opportunities created by issues such as climate change; and the system is locked in by embedded inertia and negative lobbying of many economic beneficiaries of the status quo. The result is that many – if not most – company boards still do not see sustainability as an unequivocal strategic priority.

Against a global backdrop of ever-increasing complexity and uncertainty, with continuing market turmoil, a focus on conventional economic growth, and pervasive national, regional and international policy gridlock on climate and carbon, many company leaders feel constrained in taking a longer-term view. The challenges in the system are so great that no one individual player can resolve them, and the easiest thing for most businesses is to remain focused on the short-term.

A capacity to respond?

Yet despite these barriers and the challenging market conditions, we do see some companies whose leaders have a vision that includes sustainability at its heart. These businesses are making headway in integrating sustainability into their business systems and processes by making real attempts to resolve the tension between short and long-term goals, redefining measures of success and re-examining the nature of their business models to reflect longer-term considerations. Ensuring the right attitudes and behaviours of leaders and employees will be fundamental if these companies are to succeed. The question is, how effective have companies been at integrating sustainability into their core leadership and management development programmes? And to what extent has this integration played its part in shaping organisational vision, and led to a more fundamental incorporation of sustainability into corporate strategy? In order to answer these questions, during 2012 CPSL interviewed 200 senior executives on its leadership programmes and undertook qualitative research with a small group of companies, paying particular attention to senior management development – the findings of which have informed the reflections contained in this article.

Embedding sustainability

Very few of the companies we interviewed had achieved integration of sustainability into the curriculum design of their formal executive development programmes. And even in the few instances where this was the case, the inclusion of sustainability tended to be rather reactive, in the form of bolt-on modules or sessions – typically delivered by

the sustainability director or by an outside speaker – rather than an integrated theme that permeated the whole development process and reflected the world-view of the company and the top leadership vision.

Unsurprisingly, the clearest form of specific leadership development on sustainability is usually aimed at senior executives in the sustainability function (eg sustainability directors or supply chain directors). These individuals often pursue self-selected education and training opportunities that enhance their expert knowledge on sustainability for their sector and connect them to various cross-sector initiatives and networks. The role of these functional experts is often seen as being to create and drive their organisation's sustainability vision, and to frame arguments in a way that is accessible to senior leadership teams. Occasionally they are called on to contribute to core leadership development programmes, but these tend to focus on technical issues like climate change or labour rights in the supply chain. The risk is these experts are seen as 'non-core' – technical, specialist, or even worthy, but rarely strategic.

If companies stand any chance of meaningfully embedding sustainability policies and principles into business practices and performance, they must invest in integrating sustainability into their mainstream leadership and management development programmes. But this will take some time given how strongly leadership development programmes follow the strategy and goals of an organisation, and the limited extent to which sustainability has been integrated into strategy. That is led from the top – from those who set the agenda and determine what people are going to focus on.

If companies stand any chance of meaningfully embedding sustainability policies and principles into business practices and performance, they must invest in integrating sustainability into their mainstream leadership and management development programmes, for mainstream leaders and managers. But this will take some time.

Strategy drivers

Ultimately, a successful sustainability strategy is dependent on leadership vision with buy-in from at least some of the Board or Executive Committee. Sustainability quickly makes its way into strategy when it is clearly material to the business, when it is directly linked to value creation, or when it represents a current business problem that has to be solved. But some of the longer-term sustainability challenges will not immediately show up in this way and require real understanding in the top team about the changing global context, the deep interconnectedness of many issues, shifts in societal norms, and an appreciation of how all this relates not just to the current but also the future prospects for the business.

So how is that vision and understanding created and where does the thinking that drives sustainability into strategy come from? How are leaders enhancing their thinking and capacity to respond to global challenges like poverty, loss of biodiversity and climate change? How do they develop a broader understanding of what society's general expectations are for their countries and their communities, and from the corporate sector? What are the risks and where are the opportunities? What leads to top-level commitment to sustainability? The answers certainly do not lie in traditional or formal leadership development processes or programmes.

Our experience has shown that, first and foremost, the most progressive leaders on this agenda are personally and consciously tuned into the shifting global context and societal norms, and are dedicated to understanding the implications for their business. As Jeffrey Immelt, CEO of General Electric, put it, "The most important thing I've learned since becoming CEO is context. It's how your company fits in with the world and how you respond to it." Similarly, Unilever's Paul Polman stresses the importance of context: "It is very clear that this world has tremendous challenges – the challenges of poverty, of water, of global warming, climate change. And businesses like ours have a role to play in that. And frankly, to me, that is very appealing."[5]

That thinking is rarely derived from formal leadership development processes, but rather from a complex set of interactions which exposes leaders to the latest thinking and research, deepens their intuitive understanding of the direction of travel, allows them to learn from the wisdom and experiences of others, and opens their thinking to transformative possibilities in the way they might shape their business for the future. In effect, such interactions are the real leadership developmental processes that help the top team guide the company when it comes to sustainability. They are usually external to the company; they are explicitly framed around systems thinking, and shaped by the global context and developments in societal norms. The model below summarises how these processes feed into leaders' thinking, inform the organisation's vision and, in turn, drive strategy and business practice.

Mainstream leadership development programmes tend to focus on building individual leadership skills, on motives, drivers and personal purpose, on managing for results, and in leading and building teams to compete and succeed – in other words, on leadership development that focuses on the individual and reflects existing business strategy rather than shaping it. Putting sustainability at the heart of boardroom decisions is more likely to happen as a result of leaders' active engagement with peers and other stakeholders in the external business and policy environment, in a whole range of business platforms, leadership forums, tailored sustainability programmes and experiential learning.

Going beyond the conventional

Companies that see sustainability as a competitive advantage know that they need their leaders to be able to think and operate at the cutting edge of the topic, to keep pace with a rapidly unfolding agenda, and to understand the issues before they become part of the mainstream. So they are looking beyond the 'off-the-shelf' training or conventional routes

to leadership development which tend to lag behind the latest thinking, and instead are putting their senior leaders through pioneering or specifically tailored learning interventions. The Prince of Wales's Business & Sustainability Programme is a good example of how companies develop their senior leaders' thinking through exposure to state-of-the-art-thinking and practice, and unique opportunities for cross-sector, cross-functional learning. Where more in-depth strategy sessions are needed, organisations such as Tata Sons, the African Development Bank and Unilever commission customised programmes for senior leaders, to establish a shared understanding of the global challenges, critically evaluate risks and opportunities for their organisation, and agree how to respond; while in South Africa, companies such as Nedbank, Engen, Sasol and Namdeb join CPSL workshops to identify how sustainability can unlock innovation and new forms of value creation.

Beyond these programmes which create broad awareness and understanding of global challenges, we have also seen that the most proactive leaders go further by personally engaging with sustainability issues through public discourse, collaborative enquiry, strategic partnerships and input into policy development. Each of these engagements is in its own right a powerful form of leadership development on sustainability. They go beyond what can ever be achieved by traditional, internal leadership development programmes – which, by and large, are not intended to deal with global challenges and 'wicked problems' in the first place.

Many leaders keep informed and deepen their understanding about global challenges through participation in focused, outcome-led forums designed to bring about systems-level change, whether it be through policy reform or sector change events. These include involvement in initiatives such as the World Economic Forum, the Clinton Global Initiative or leadership meetings of the World Business Council for Sustainable Development (WBCSD). Others engage in leadership platforms, such as those run by CPSL, to find shared solutions for wicked problems or to join forces to champion policy change. CPSL examples of such business platforms are summarised in **Table 1** below.

Another form of 'learning by doing' is senior leaders' involvement in cross-sector partnerships. These will typically require top leadership commitment and brokering processes which in themselves deepen understanding and build senior leaders' capacity. A recent example of this is GlaxoSmithKline's partnership with Vodafone to harness innovative mobile technology to help vaccinate more children against common infectious diseases in Africa, spearheaded by Sir Andrew Witty, CEO of GSK, and Vittorio Colao, CEO of Vodafone. Another example is the CEO-led Deforestation Partnership in the Consumer Goods Forum (CGF), which has teamed up BEI banking leaders to determine how the banking industry can align with the CGF goal of eliminating Forum's contribution to deforestation in its supply chains by 2020.

These projects will never appear as leadership development processes, but in most successful instances top-level buy-in – and thus a greater degree of understanding – is a key ingredient. Experiential learning, on the other hand, is a more explicitly recognised form of leadership development. Here, learning is seen as a process of self-discovery, rather than knowledge transfer. Typically, participants are required to respond to a real-world challenge beyond the scope of their experience. It is rare for top leaders to be able to find the time to undergo such a process, but there are cases such as the legendary 2001 Unilever leadership journey to Costa Rica which was seen by many as transformative in the company's response to sustainability. More recently, former CEO of TNT, Peter Bakker, now at WBCSD, required his top leadership team to be directly involved in projects of the World Food Programme as a transformational leadership experience. Similarly, many CEOs have had life-changing insights through participating in The Prince's 'Seeing is Believing' Programme. The key to the effectiveness of such experiential learning programmes is immersion in an unfamiliar and challenging environment that stimulates creative thinking and deep reflection in an unfamiliar context.

Table 1: CPSL Business Platforms & Leadership Forums

ClimateWise	Brings together 40 of the world's leading insurance companies to reduce climate risk to a manageable level
Natural Capital Leaders Platform	Influential companies addressing the impacts of ecosystem and natural capital degradation on business, customers and society
Banking Environment Initiative (BEI)	CEOs of some of the world's largest banks working to redirect capital towards sustainable, low-carbon growth
The Prince of Wales's Corporate Leaders Group on Climate Change (CLG)	Business leaders from major UK, EU and international companies calling for new and longer-term policies for tackling climate change

Conclusion

Leaders who are most effectively integrating sustainability into their organisation's strategy have a clear vision that is informed by the changing context. These individuals are deriving knowledge, insight and inspiration from a rich and complex set of external interactions with their peers, within a diverse network of stakeholders, and from sustainability learning experiences. They have found new pathways to gather insight beyond the formal leadership development processes offered by their companies.

In future, as sustainability becomes more strategic, we expect mainstream leadership development programmes to change quite radically: to become more proactive (rather than responsive) and to put the individual's development into a much richer global context shaped by social and environmental trends and emerging norms. Until this happens, parallel processes of engagement – effectively 'learning by sharing and doing' – will remain critical to the development of that all-important leadership vision and leaders' capacity to shape the strategy that can respond more effectively to our most pressing sustainability challenges.

[1] Potsdam Institute for the World Bank, 2012. *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*

[2] Accenture, 2010. *A New Era of Sustainability: UN Global Compact – Accenture CEO Study*

[3] McKinsey, 2011. *The Business of Sustainability*

[4] Internal survey of 200 senior leaders taking part in CPSL Executive Programmes in 2012

[5] McKinsey, 2011. *McKinsey conversations with global leaders: Paul Polman of Unilever*

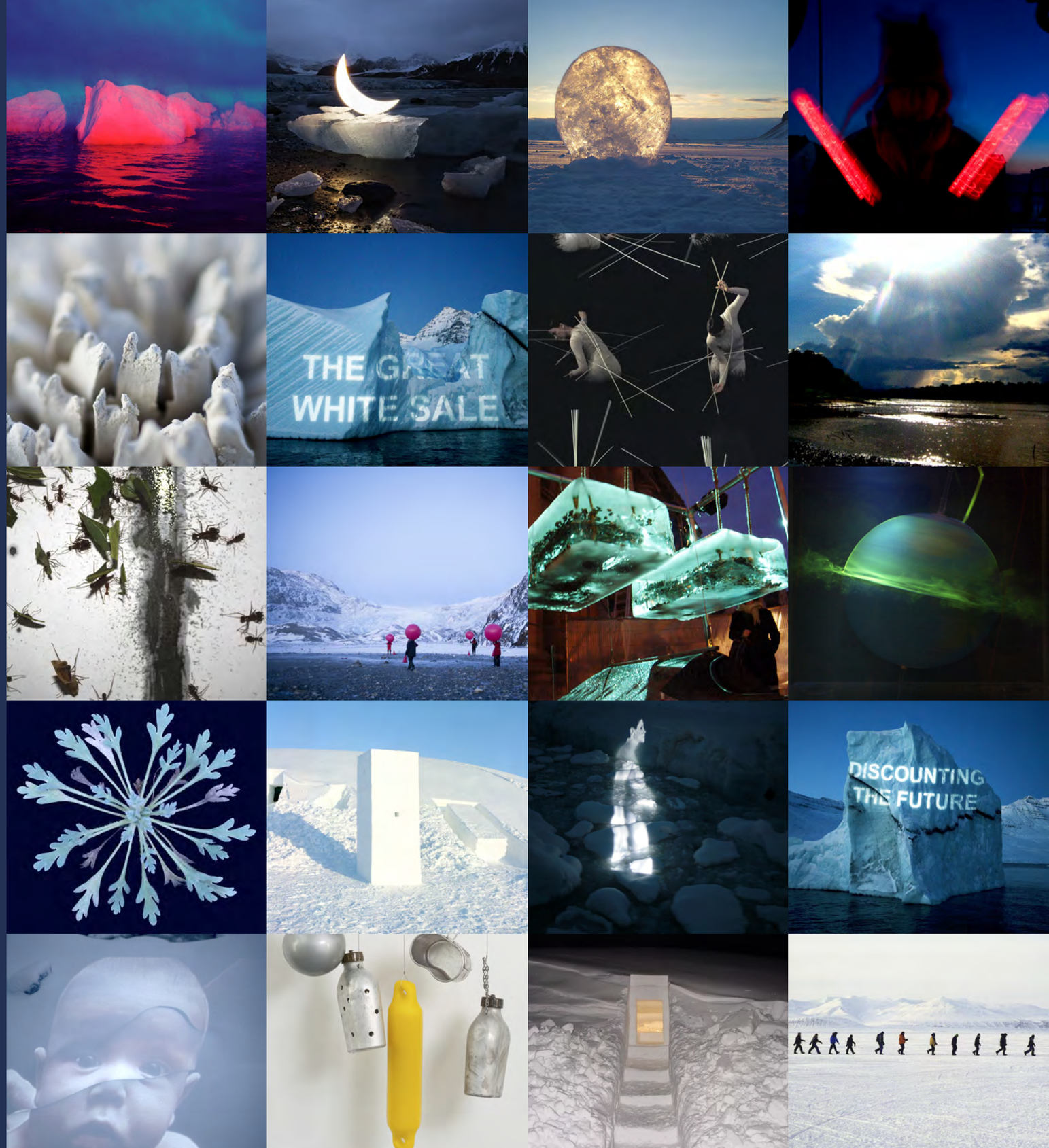
Having voyaged to the Arctic with Cape Farewell in 2010, a year later Leonid Tishkov created the exhibition *Arctic Diary*, reflecting on his experiences in the far north. "Miracles can happen in this realm: the moon comes down from the heavens, glistening polar bears walk on ice floats, white clouds bathe in the sea together with blue whales, and delicate icebergs float in the sky. The snow there emits light and the melting glacier calls out to us, humans, whispering 'I am still alive...'"

THE FUTURE IN PRACTICE

THE STATE OF SUSTAINABILITY LEADERSHIP

Introduction: The Future in Practice

Mike Peirce



Introduction: The Future in Practice

Mike Peirce

Mike Peirce is Director of Strategy & Communications at the University of Cambridge Programme for Sustainability Leadership. Formerly Chief Operating Officer at AccountAbility, he is a member of the International Advisory Board of The Future We Want, and a Trustee of development education charity Think Global.

The idea of the long term, and of avoiding 'short-termism', has become a dominant topic in business and sustainability debates. From frameworks to measure organisations' adaptive capacity, to calls for a radically new form of long-term leadership; from thinkers who argue we are intellectually, and perhaps morally, ill-equipped to consider the future, to researchers who find that the public is fundamentally altruistic towards future generations; and, in the finance and investment worlds, from critiques of capital market short-termism, to calls for 'capitalism for the long term' and shifts away from quarterly profit reporting – it seems that the question of how far business leaders and policymakers can envisage or influence the future has never been so hotly debated.[1]

This flurry of discussion about the long term culminated in the UN's decision to brand the Rio+20 World Summit on Sustainable Development 'The Future We Want'. Pervading many of the conversations at Rio and elsewhere were successive layers of pessimism and of optimism. For some, there appears to be a sense of failure at what is being achieved now, in the face of gloomy prognostications about what will happen in the future. For others, there is a sense of needing to define and understand the future, so that companies, policymakers and individuals can get on with practical action to make a difference.

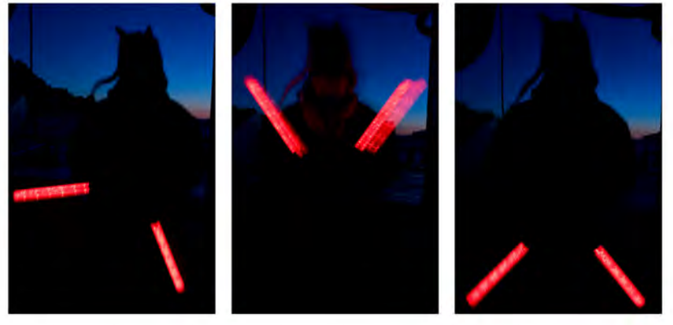
[1] See the work of Tom Gladwin at the University of Michigan; John Elkington, *The Future Quotient: 50 Stars in Seriously Long-Term Innovation* (2011); Stephen M Gardiner, *A Perfect Moral Storm: The Ethical Tragedy of Climate Change* (2011); the Alliance for Future Generations; Andrew Haldane at the Bank of England; Dominic Barton, McKinsey & Co; and Paul Polman, Unilever.

Sustainable development thinking is grounded, of course, on considerations of "the ability of future generations to meet their own needs".

Perhaps we should not be surprised at these arguments about the long term; sustainable development thinking is grounded, of course, on considerations of "the ability of future generations to meet their own needs" (Brundtland Report, *Our Common Future*, 1987). And business, while considered by some critics an unlikely champion of the sustainability cause, nonetheless has a strong tradition of long-term analysis, planning and investment, as well as frequently placing the long term at the heart of organisational vision and purpose.

Given our focus on working with business leaders, the University of Cambridge Programme for Sustainability Leadership (CPSL) decided to join the debate by adopting the future as our theme for this year's review of **The State of Sustainability Leadership.** We hoped to tease out what we may expect from the next 50 years, as well as highlighting progress towards factoring that future into business decisions today.

We focused on leadership for the long term, 'The Future in Practice' – asking people from business, finance, academia and cultural institutions how executives could think far-sightedly, and interpret their responsibilities towards future generations. How could they discover the likely implications of decisions they would be taking in the coming months and years? We invited these contributors to think long-term, but also to consciously avoid the abstract, keeping focused on the priorities of today. Sometimes the long-term thinking they outline is very much to the fore of their articles; in other cases it lies more subtly behind the stories that they tell.



Here Comes The Sun – There Goes The Ice, Chris Wainwright (2010)

The report is framed by a piece from Polly Courtice, CPSL's Director, who examines how companies are building long-term sustainability thinking into their strategy. Based on her recent research with senior executives, HR directors and sustainability champions, she argues that highly effective leaders are developing the basis for their sustainability vision through a complex set of external interactions with peers and other stakeholders, and through sustainability learning experiences that have little to do with the formal leadership development processes offered by their companies. "Some of the longer-term sustainability challenges... require real understanding in the top team about the changing global context, the deep interconnectedness of many issues, shifts in societal norms, and an appreciation of how all this relates not just to the current but also the future prospects for the business."

We then open **The State of Sustainability Leadership** with a series of future projections, 'Framing the Future'. In our first chapter, Professor Jorgen Randers reviews the effectiveness of his life's work after four decades of campaigning for sustainability, and predicts what the next 40 years will bring. In this article based on his Cambridge Distinguished Lecture of 2012 and his book *2052: A global forecast for the next forty years*, he blames short-termism for a series of likely outcomes, including an environment damaged by climate change,

Leafcutter Ants, Daro Montag (2011)

starvation driven more by skewed income distribution than by a shortage of land, and a declining sense of wealth in currently 'developed' nations.

If Jorgen Randers believes that lower-than-expected population growth will, nonetheless, mitigate the worst effects of approaching resource scarcity, hedge fund manager and co-founder of GMO LLC Jeremy Grantham puts a crisis in commodities – in particular, water, soil, phosphorus, and potassium – at the heart of his narrative for the future. In this adapted version of his high-profile lecture to delegates at The Prince of Wales's Business & Sustainability Programme 2012, he uses the history of stock-market bubbles to explain why we should concern ourselves with broadening our vision and learning lessons from the past.

Former DeutscheBank financier Pavan Sukhdev takes a closer look at our immediate priorities. Now leader of UNEP's landmark project The Economics of Ecosystems and Biodiversity, Sukhdev argues that within the next decade we need a new corporate paradigm to meet the challenges of delivering a green and equitable economy. He proposes four 'planks' to this new model for 'Corporation 2020': disclosing externalities, accountable advertising, limited leverage over public funds, and resource taxation. His approach demands what he describes as an unprecedented level of collaboration across government, business and civil society.

For the last chapter of this section we turn to a vivid crisis of the present – the economic turmoil within the European Union and beyond. The Director of CPSL's Brussels office, Sandrine Dixson-Declève, outlines the current status of sustainability issues in the corridors of power in Europe. With many political leaders preoccupied by the Eurozone crisis, now is the time, she argues, for business to take a lead, deploying its influence to create the political space for forward-thinking regulatory action.

The second section of **The State of Sustainability Leadership**, 'Building the Future', presents a series of business responses to Randers', Sukhdev's and Dixson-Declève's challenge, including contributions from a Brazilian petrochemicals company, a South African bank, and a global food giant. Leaders from this range of international companies highlight the importance of consumer and other competitive pressures that are placing sustainability at the core of their corporate strategy, and, reiterating a developing theme, the need for a mature dialogue between business and government in generating creative solutions.

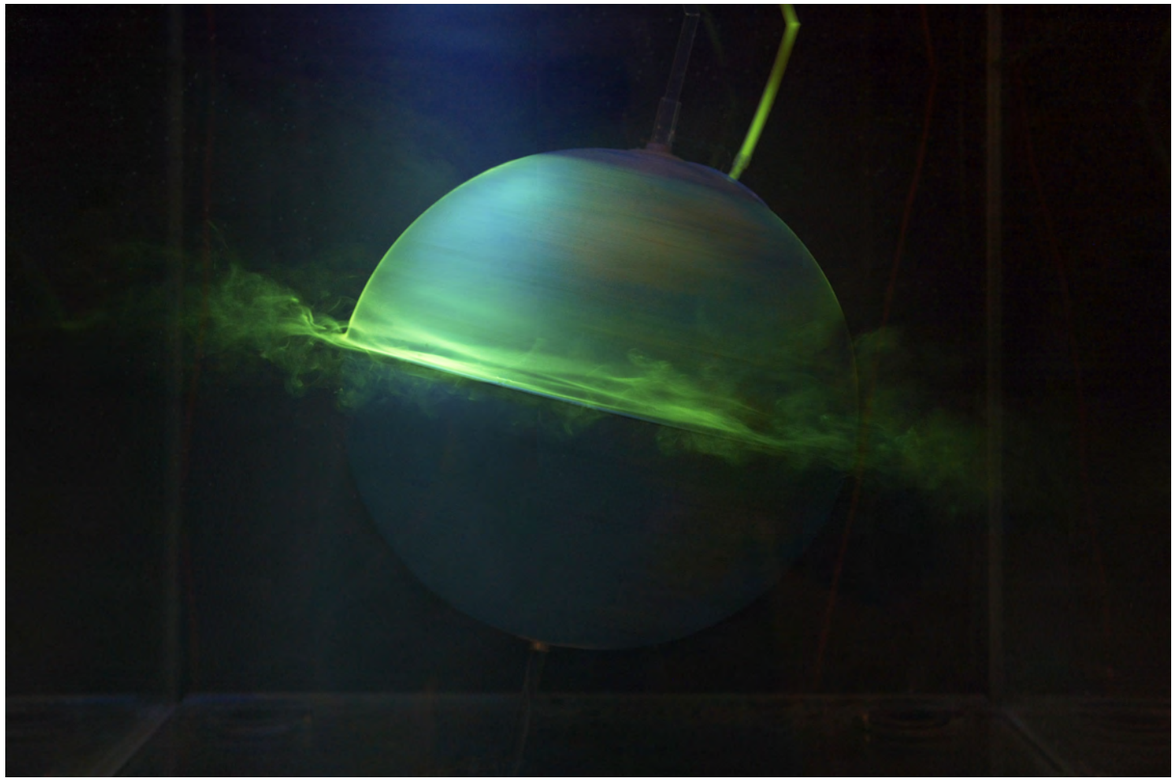
The CEO of Braskem, Carlos Fadigas, describes his vision of sustainability integrated into core business objectives, and why he believes this need not mean an end to competitive advantage. Only with the participation of 'the economic mainstream', he points out, can we achieve results on the scale required. Mike Brown, Chief Executive of major South African bank Nedbank, describes the personal impact of learning about the '2°C limit', why he feels this 'hard' technical and ethical boundary may be just what's needed for business to engage, and how our leaders' creativity and innovation must match the very inflexibility of this goal. In the following article, José Lopez, VP for Operations at Nestlé S.A., outlines why our treatment of natural resources is a concern to the company, and his determination to champion the 'natural capital' upon which Nestlé's business is based.

How could executives think far-sightedly, and interpret their responsibilities towards future generations? How could they discover the likely implications of decisions they would be taking in the coming months and years?

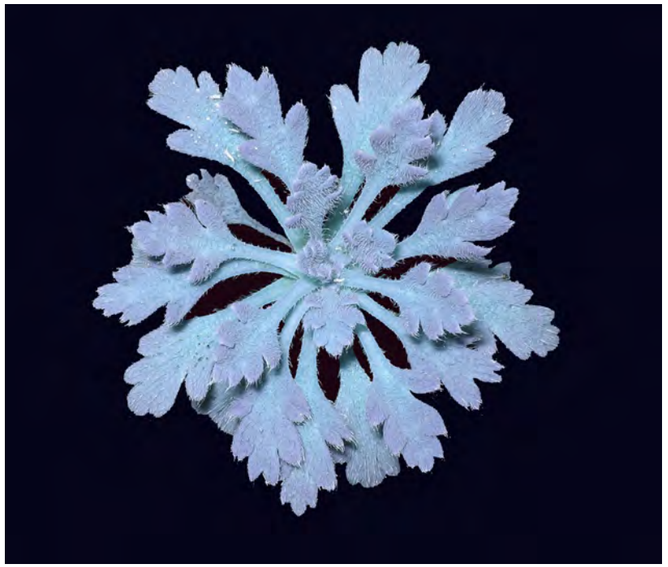
Our academic contributions demonstrate the breadth and diversity of possible intellectual approaches to long-term challenges, and touch on real-life, practical choices faced by business leaders and policymakers every day.

The next section, 'Investigating the Future', highlights four areas of research from outstanding Cambridge academics. Such intellectual arguments could be seen as more abstract; they are certainly less rooted in the urgency of decisions that need to be made today. Yet the four contributions – from an engineer, a mathematical biologist, a human geographer and a social scientist – demonstrate the breadth and diversity of possible intellectual approaches to long-term challenges, and all touch on real-life, practical choices faced by business leaders and policymakers every day.

Dr Julian Allwood, former IPCC author, is convinced that energy efficiencies in production will not be enough to reach the UK's carbon emissions targets. Grounded in data and wide-ranging research into industrial efficiency, his argument calls for a new approach to material efficiency – 'sustainable materials, with both eyes open' – as well as a new vision of product lifecycles to help us build a sustainable future.



Domestic Disaster 3: Planet Earth, HeHe (2012)



Arctic Poppy Chronicles, Michèle Noach & Ian Martin (2012)

Revisiting Jeremy Grantham's concern with how we will feed our growing population, Professor Chris Gilligan explains that improved responses to crop disease and pests must play a major role in boosting agricultural productivity. The toolkit developed by his Cambridge team, coupled with insights from the social sciences and humanities, aims to provide policymakers with the information they need to make informed and timely decisions on this crucial issue. Collaboration between the private and public sectors, he argues once again, is essential.

Next, Dr Bhaskar Vira introduces us to the political economy of ecosystems services – the complex social and political questions behind attempts to set a value on natural resources. Who gains, who loses in choices over nature conservation? Without asking these questions, we will miss out on just and equitable, not to mention realistic and sustainable, solutions to preserving the resources championed by José Lopez and other leaders.

Returning to the theme of emissions, Dr David Reiner focuses on what we can learn from the controversies surrounding an area of major technical innovation and potential investment – carbon dioxide capture and storage. His explorations of the views of different environmentalists, and the way politicians and the energy industry communicate with the public, reveal challenges both for the 'green' movement and for the whole of society, as we try to establish trust and consensus in the face of climate change. He calls for greater leadership from those with the resources and experience to open up genuine dialogue – policymakers and the energy industry.

We close this publication with a cultural perspective from David Buckland, the creator and director of Cape Farewell, which works with artists and scientists on a cultural response to climate change – and which has provided the stunning images in this year's report. Echoing David Reiner's concern that we raise significant risks by relying on technology without adequate public debate, David Buckland explains why the arts have a vital role to play in driving humankind's response to the climate challenge.

So what can be gathered from these contributions – and, in particular, what are the implications for business leaders and policymakers?

In last year's **The State of Sustainability Leadership,** Polly Courtice's article, 'The Challenge to Business as Usual', introduced CPSL's model of leadership for sustainability. This encompassed three interacting elements: context (both internal and external to an organisation); individual characteristics (such as styles, skills and knowledge); and actions (both internal, such as strategic direction, and external, such as partnerships and products & services).

A parallel trio of elements can be observed in this year's articles, with leaders seeking to:

Envisage the future – whether via scenarios or visioning, forecasting or backcasting, stakeholder analysis or one of numerous other techniques;

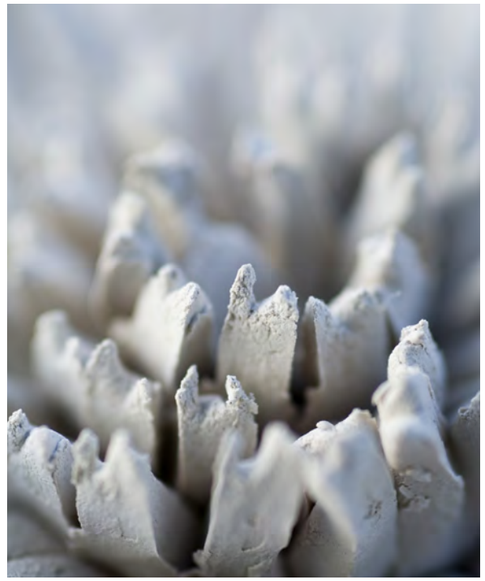
Prepare for the future – in terms of building skills and adaptive capacity, and taking bets on likely market and societal developments; and

We hope to offer readers some sense of hope and agency, and encourage them to embark on their own journeys of envisaging, preparing for, and even influencing our shared future.

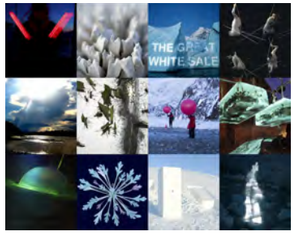
Influence the future – whether by shaping future markets and the policy environment, or through research and product development, long-term investments and new forms of collaboration.

The current fascination with the future demonstrates that the most important ideas come around time and time again. At another moment of social upheaval and high idealism, the eighteenth-century Enlightenment, Voltaire commented that "the present is pregnant with the future".

It is our hope that, in the face of all the challenges ahead, **The State of Sustainability Leadership** will offer its readers in business and beyond some sense of hope and agency, and encouragement for them to embark on their own journeys of envisaging, preparing for, and even influencing our shared future.



Blossom, Clare Twomey (2008)



The images in **The State of Sustainability Leadership** were kindly provided by Cape Farewell, which works with artists and scientists on a cultural response to climate change. www.capefarewell.com

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Section One

Framing the Future

2052: A global forecast for the next forty years

Professor Jorgen Randers

Here Comes The Sun – There Goes The Ice, spelled out in semaphore by artist Chris Wainwright, using the Arctic dusk as his canvas.

2052: A global forecast for the next forty years

Professor Jorgen Randers

Jorgen Randers is Professor of Climate Strategy at the BI Norwegian Business School. He is a non-executive member of a number of corporate boards in Norway, and sits on the sustainability councils of British Telecom in the UK and The Dow Chemical Company in the US. He chaired the Commission on Low Greenhouse Gas Emissions, which reported in 2006 to the Norwegian cabinet on how to cut emissions by two-thirds by 2050. He was President of the Norwegian School of Management 1981–89, and Deputy Director-General of WWF International in Switzerland 1994–99. He has authored a number of books and scientific papers, and co-authored *The Limits to Growth* (1972) – the original report to the 'Club of Rome' – and its two sequels in 1992 and 2004.

If I could persuade you of one thing, it should be this: the world is small and fragile, and humanity is huge, dangerous and powerful. This is a total reversal of the biblical perspective on humanity, and the way in which man has thought during most of his presence on Earth. But this is the perspective we need to take if we're to be sure that sustainability emerges or, at least, that the world as we know it survives for a couple of hundred more years.

I have spent the past four decades trying to make the world a sustainable place, preaching about what ought to be done from all kinds of different positions. Last year, I succumbed to the temptation to try to think through what will happen over the next 40 years. Not what I would *like* to happen, but what the parliaments and voters and semi-authoritarian regimes of the world will actually do. How is that future going to look? This is, of course, much less of a scientific activity than the type of scenario analysis I commonly do; it is educated guesswork. This article is about what I found in my crystal-ball-gazing exercise.

The danger in forecasting is, of course, that if one sees something ugly coming up it might demotivate the constructive forces trying to create a better world. The main reason why I still wanted to look ahead was because I have only about 20 more years to live, and I want to optimise my remaining years rather than continuing to struggle in directions which might be hopeless. So, partly, *2052* was written for my own purposes. Secondly, I am so old that I've started to evaluate the effect of how I've spent the past 40 years, and I'm fairly sceptical about what we old gentlemen who created and ran the environmental movement have been able to achieve. But in order to make that assessment properly, one needs to know what will happen over the next 40 years, to see the effort in full perspective. Finally, I hope my analysis can be used for something constructive. Once you know what will happen, it's much easier to derive where one should put in one's own little effort in order to create a better future. Instead of working against something which may be hopeless, you can try to concentrate on an area where you might trigger some serious results.

My forecast is internally consistent and draws on a broad base of knowledge, with a strong sense of causality; I think I understand *why* fertility develops the way that it does, *why* societies only invest 25 per cent of their GDP, and so on. I have also had advice and criticism from world-class experts. But while my forecast is as good as I can make it, forecasting is not a scientific activity. Things could happen tomorrow to put us on a totally different path; nothing is totally fixed. We will see in 40 years if it was worth the effort.

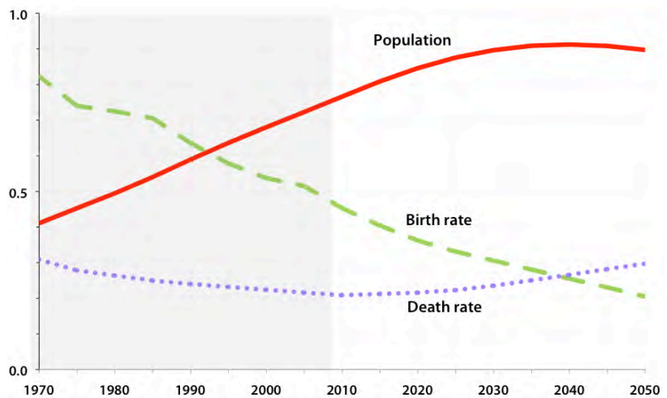

Figure 1: World Population 1970–2050. Scales: Population (0–9 billion people); birth and death rate (0–4 per cent per year).

I don't like what I see. This is not the world I would have created if I were in charge. It is not the kind of future I have been working for all along.

One final introductory comment: I don't like what I see. This is not the world I would have created if I were in charge. It is not the kind of future I have been working for all along.

So let me walk you through the future, as logically as I can. Most of the graphs which follow cover the period 1970–2050, based on a spreadsheet model which describes the world as a sum of five regions. The shaded area to the left represents historical numbers, and my forecast appears to the right. I'll address population, world GDP, wealth and investment, resources, food, water, energy, temperatures, and wilderness over the next 40 years.

Future population

When people think about the future, world population often comes first. My forecast, as you can see in **Figure 1,** is that the population will peak in 2040 at 8.1 billion people, and then start to decline and continue declining throughout the second half of this century. This is very low compared to the UN forecast, which talks about 9 billion people in 2050 and numbers rising from there. I have such a low forecast because I think fertility trends will continue downwards at the stupendous rate that has occurred over the past 40 years.

The number of children per woman throughout her reproductive years used to be very high, but this is falling very quickly due to the education of women, increased urbanisation, and more easily-available contraception.

This article is adapted from Professor Randers' lecture in the 10th Annual Distinguished Lecture Series in Sustainable Development, hosted by the University of Cambridge Programme for Sustainability Leadership and the Centre for Sustainable Development in the Department of Engineering on 14 March 2012. It is based on his most recent book, *2052: A Global Forecast for the Next Forty Years* (2012) – also a report to the Club of Rome – with permission from Chelsea Green Publishing, www.chelseagreen.com. *2052* is distributed in the UK by Green Books, www.greenbooks.co.uk. All figures in this article are extracts from *2052*, and the data is also available at www.2052.info.

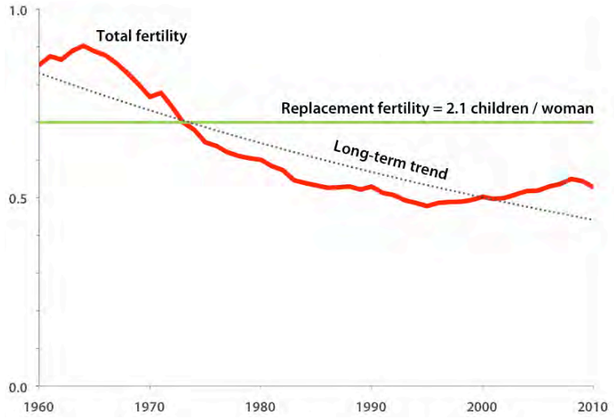

Figure 2: Fertility decline in EU15, 1960–2010. Definition: Total fertility = number of children born to each woman on average throughout her reproductive life. Scales: Total fertility (0–3 children per woman).

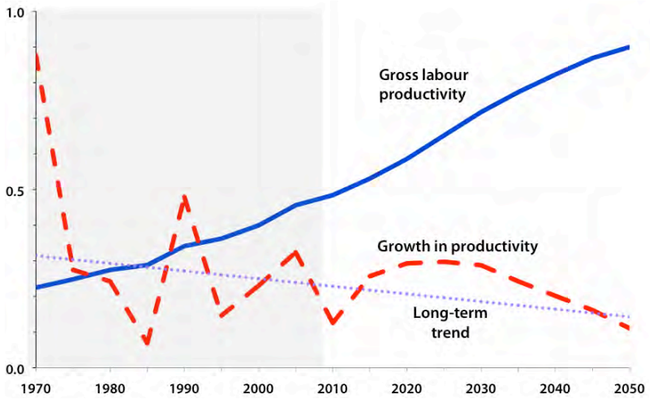

Figure 3: World gross labour productivity, 1970–2050. Definition: Gross labour productivity = GDP divided by people aged 15–65. Scales: Gross labour productivity (0–20,000 US$ per person-year); growth in productivity and long-term trend (0–7 per cent per year).

Even poor people (I mean this ironically, of course) are wise enough to understand that having a large family is not a good idea when you live in an urban area. It was a good idea to have many children in the countryside when people were farming their own food, but it doesn't work in cities. You can see this already in existing fertility statistics, which are coming down very rapidly.

The downward trend in fertility is countered by increasing life expectancy. In my forecast, life expectancy rises to around 75 years as a world average by 2050, because I think medical progress is going to continue over the next 40 years. But the effect of declining fertility is stronger than the effect of rising life expectancy, which means the global population will actually plateau around 2040. This may be surprising to you, but we have already seen a decline in the Japanese population, for example, for a decade because of this combined effect. Furthermore, Germany is already plateauing. Among the rich countries it is only nations like Norway and the USA, with wide-open borders and a lot of immigration, which still have rapid population growth. China's population will peak in 2030 because of the continuation of Deng's wise one-child policy, which will help solve China's biggest problem: how to create a sustainable society within the country's borders. The reason why the death rate rises in Figure 1 is that the number of old people will rise faster than the rise in life expectancy over the next 40 years.

For those of you who doubt my central assumptions here, **Figure 2** shows fertility in the EU15 over the past 50 years. When total fertility falls below 2.1 children per woman, the population will decline in the long run, and this has been the case in the EU since 1970. Had it not been for immigration, the population would have been declining. Extreme cases like Italy, for example, have had a fertility rate of 1.3 for decades. Italian women don't want to have children because it's difficult to combine children and a job in Italy; then, experience shows, women overwhelmingly choose to have a job. So things are already developing along the lines of my forecast.

Future world GDP

Next, people are generally interested in world GDP. What will be the total global production of goods and services? The way I calculate future GDP is to take the number of people who can work – say, everyone between 15 and 65 – and multiply this number by how much each of them produces per year. The upper curve in **Figure 3** is the aggregated productivity, the gross output of goods and services per person in the potential workforce. I predict that the output per person will continue to increase, but at a declining rate, and that it will level off around 2050.

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If you multiply a workforce which is declining with a productivity that reaches a plateau, you get a GDP which will plateau around 2050 and then start to decline. This is what happens in my forecast: something no Wall Street or City analyst would ever dare to think about. The world production of goods and services levels off, and finally – in the second half of the century – starts a continuing decline.

Why is the growth rate in productivity declining? The reason is that when an economy matures, all the people who were initially working in agriculture shift into manufacturing, and then onwards to service production. Then, as an economy gets really rich, like in Norway and the US today, most people end up working in services and ultimately in social care. Finally, you get to a point where there are so few people in agriculture, forestry, fisheries, and manufacturing that any productivity increase has to occur in services. But increasing productivity in offices, research groups, universities or care homes isn't easy. So the productivity rise slows once you move towards a mature economy.

In **Figure 4,** for example, you can see that in the early 1950s the US economy was growing at 4 per cent a year. (The trend is more important than the fluctuations around it.) Now that the US economy is more mature, you can see that the trend has come down to below 1 per cent a year. If you extend the forecast to 2020, there will be no productivity growth. And the US is the world's most productive economy, so it shows where everyone else will end up.

Figure 4: US gross labour productivity, 1950–2010. Definition: Labour productivity = GDP divided by people aged 15–65. Scales: Change in labour productivity (-6.0 to 10 per cent per year).

It's not only the City analyst who will worry about my forecast of slowing economic growth in the rich world over the coming decades; most people feel that growth is desirable. The fundamental reason why most people favour growth is that it is the only way modern society has found to solve three problems effectively: poverty, unemployment, and pensions. Economic growth reduces poverty at the national level by increasing average labour productivity. Growth furthermore increases total employment, and providing new jobs is the only politically feasible technique to achieve the large-scale redistribution of income in a capitalist society: if you have a job, at least you get a piece of the total pie. Thirdly, growth is needed to fund pensions, especially in an ageing population.

If society were to get away from growth, it would need an alternative which simultaneously eliminated poverty, solved unemployment and provided adequate pensions. That alternative is not obvious, hence society pursues old-fashioned economic growth. Another solution could be to stabilise GDP and distribute that finite production in an equitable manner. This would take a wise populace! The majority would have to resolve that, rather than expanding the production of goods and services every year, they would instead keep production constant, taking increasing amounts of leisure time, and redistributing outputs. They would deliberately shift work and income from those who have a job, and give to those who don't. It's doable, but is very unlikely to happen at scale during the next 40 years. Authoritarian regimes like China might succeed, that is, create employment in spite of the market; and some will do so with positive results. But in free-market democracies it is unlikely that large-scale redistribution will happen in a peaceful

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manner. As a consequence, these societies will continue to strive for growth – but with less and less success.

Returning to my growth predictions, the industrialised world (Europe, Japan, Australia, New Zealand and the mature East Asian tiger economies) will follow in the tracks of the United States, with gradually declining growth rates. China and other successful emerging economies will catch up, but while these latter countries are capable of showing very high economic growth rates for a while, these too will decline as they catch up with the old industrial world. You can already see this happening in China: in the current Five Year Plan, the planned growth rate has been lowered from something like 10 per cent per year in the past to 7.5 per cent in the future. I am afraid I believe that the poorest region I look at, containing the world's poorest 2 billion people, will continue to experience the same slow growth in the next 40 years as it did over the past 40, and therefore still be rather poor in 2052.

In summary – and everything else follows from this view – the world population will grow for a while, but stagnate at some 8 billion people around 2040 and then decline. Global GDP will continue to grow, but not at the rates we have been used to in the past; and the total world economy will stabilise after the middle of this century, passing 2.2 times current GDP in 2052.

Future investment share of GDP

In rough terms, world GDP will double in the next 40 years. Global society will be producing roughly twice as many goods and services, and since the population will only grow from 7 billion to 8 billion, average consumption per head will go up.

But there is one very important and third central idea in my forecast: a substantial increase in the fraction of GDP which will be required for investments in infrastructure and the like – the 'investment share' of GDP. Over the next 40 years, in addition to all the resource, pollution and inequity problems that we have already, humanity will run into more problems of depletion, pollution, adaptation, repair of climate damage, etc, because we will be trying to fit an excessive amount of activity onto a small globe. At first, society will pretend that the problem does not exist. Then, after a while, we will start understanding that the problem is real – for example, that there isn't any cheap conventional oil left. At that time we will (grudgingly) put up the necessary money in order to get oil from the Arctic, from a great depth, or from shale oil.

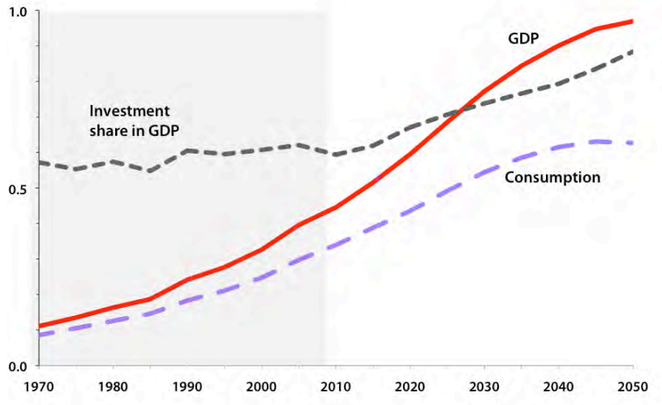

Figure 5: World production and consumption, 1970–2050. Scales: Consumption and GDP (0–150 trillion US$ per year); investment share (0–40 per cent).

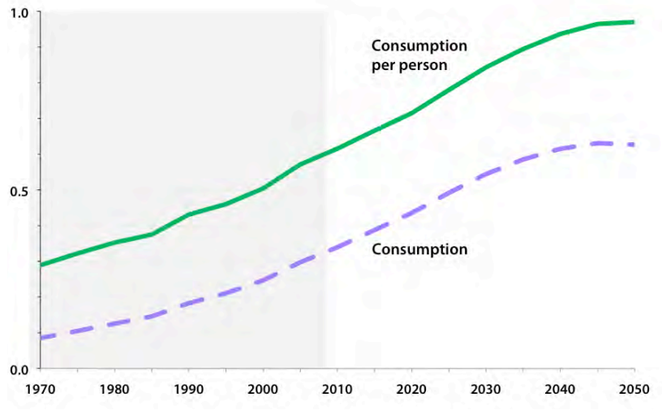

Figure 6: World consumption per person, 1970–2050. Scales: Consumption per person (0–12,000 US$ per person-year); consumption (0–150 trillion US$ per year).

Similarly, once climate damage destroys homes and infrastructure it will be necessary to spend funds on reconstruction. And the same with pollution damage. When CFCs destroyed the ozone layer, money was allocated to the invention of new technologies, and to build new factories to produce a substitute.

So I believe we will be facing an increasing number of problems over the next 40 years, and that society will respond by making investments in order to try to get rid of these problems. I have tried to estimate how much this will cost. World GDP can be divided into consumer goods (the goods and services that we consume each year in order to be happier) and investment goods (the things we produce in order to have consumption in the future). As you can see from **Figure 5,** the investment share of spending has been around 25 per cent of GDP over the past 40 years – amazingly stable. We consume three-quarters, and invest one-quarter in infrastructure to support future consumption: roads and factories, ships, anti-pollution equipment, education and so on. Lord Stern has estimated that dealing with the climate problem will cost around 1–2 per cent of GDP. This means that we will need to invest 26–27 per cent of future GDP to live in a world without climate damage. Adding in all the other things we need to spend money on, such as more expensive energy systems which don't run on fossil fuels, I predict that in an extreme case we might have to increase the investment share up to about 40 per cent. This growth in investment, of course, means that consumption will not grow as rapidly as GDP.

What about future employment? Luckily the number of jobs is not governed by consumption alone. You also need people to produce investment goods and services. Total employment is governed by GDP, and thus increases irrespective of whether we increase the production of toys for kids or of offshore oil platforms. Both consumption and investment involve jobs. The difference is that in the first instance, you produce a consumer good which people enjoy in the short term. In the second case, you produce a future income stream which will make people happy in the future instead. So my forecast is that we will shift more of the world's labour and capital away from the production of consumption goods and services, towards the production of investment goods and services. That means that disposable income will not grow as fast as it would otherwise. This is illustrated in **Figure 6,** using consumption per person.

This graph shows the global average, but hides surprising results at the regional level. For example, per capita disposable income in the USA will stagnate over the next 20 years, and then go down for the following 20 years, in spite of continued hard work by its people. The decline will not be associated with unemployment; the decline in purchasing

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power will occur because the US will have to use a much larger portion of its workforce and its capital on investment goods, rather than on the production of consumer goods. The same thing, more or less, is the case with Europe, but Europe is in a slightly better starting position because it doesn't have a huge debt like the US.

Future resources

Many people believe that there are not enough resources – minerals and crops – in the world to solve the problems we face. I disagree. It seems to me that, luckily, because of much slower population and economic growth over the next 40 years, we will have enough of everything to maintain the expansion. In *2052*, I calculate the 'non-energy footprint' of humanity. This is the amount of land needed to maintain our current standard of living: crop land for food, grazing land for meat, forest land for wood, fish banks for fish, and the land we use for infrastructure and urban areas. Luckily, this non-energy footprint is well below the amount of available land, which I refer to as the world's 'biocapacity'. It is true that the amount of surplus unused biocapacity is being reduced (see Figure 12, below); and, yes, this discussion of land use disregards the climate effect, which must be included in the full footprint. But as long as we limit ourselves to physical land, there seems to be enough for the next 40 years.

Beyond that, around 2050, I expect us to start seeing the destruction of the global ecosystem. Our current ways are not sustainable in the long run. But my forecast only examines the next 40 years.

Many people seem to believe that limited oil is going to stop expansion. I think not. The production and use of conventional oil, measured in million tons of oil per year, already peaked in the early 1980s. Total oil consumption, however, of course continued to grow: humanity simply moved from the most easily available conventional oil, which you got in Texas or in Saudi Arabia by literally sticking poles in the ground, to less accessible deep offshore oil, which requires expensive investments in monstrous platforms. These days, unconventional and expensive shale oils are also entering the picture.

In my forecast there will be enough oil to cover demand, but the cost of producing it will go up, and so will the costs of production in terms of environmental damage. Furthermore, demand will stagnate and then decline as renewables take over. So I don't foresee a real oil crisis, nor do I see any other resource crises on the horizon. I only see a shift from cheap materials to more expensive substitutes, and luckily, it looks as if the shift is going to be fast enough to avoid the type of shocks that might derail the whole system. But once again, this 'optimistic' forecast is a consequence of the slow global growth I expect in GDP over the next 40 years.

Future food

On the food side, what do I think? There will not be enough food to avoid starvation completely, but there will be enough food to feed those who can pay. The world can produce very much more food than it does today. The reason it does not is that the world's hungry cannot pay what it takes to convince farmers to make the extra-cheap food they require. In other words, our ability to produce a lot of expensive food does not solve the problem of those who starve. There are currently some two billion relatively poor people in the world. In my forecast, there will be about the same number in 2050. This is one negative side effect of slower economic growth: in the next 40 years, growth will primarily be in China and in the big emerging economies. In the rest of the world, many will stay poor and unable to buy enough food.

Those who can afford food will eat better and better, while the poor will remain hungry… Starvation is the effect of skewed income distribution, not a physical lack of food.

Agricultural land use has, more or less, been constant for the past 40 years; it will increase a little over the next 40 years because there is land in Brazil, the former USSR, and elsewhere. So we have land available, and as the purchasing power of the Chinese continues to increase, there will be increased food production. This will be done by increasing yields by adding more fertiliser, irrigation, and GMOs. If we take food production (the red line on **Figure 7**), and divide by population, you see that food production per person (the blue line) will also go up – at least a little. Presently, the average food per capita in the world is 2–3 times subsistence levels. So, we are already at a fairly high average food production, and this

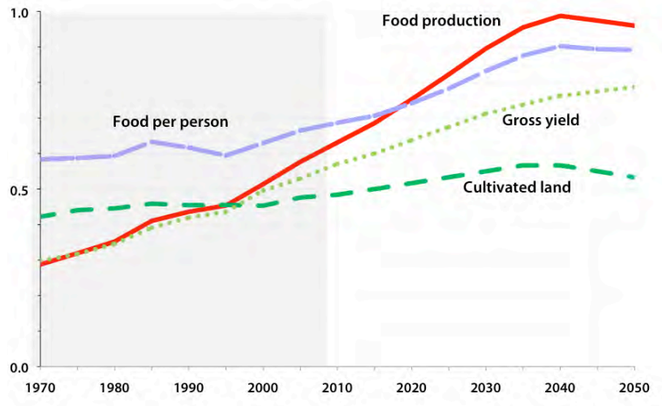

Figure 7: World food production, 1970–2050. Scales: Food production (0–10.5 billion tonnes per year); cultivated land (0–3 billion hectares); gross yield (0–8 tonnes per hectare-year); food per person (0–1.4 tonnes per person-year).

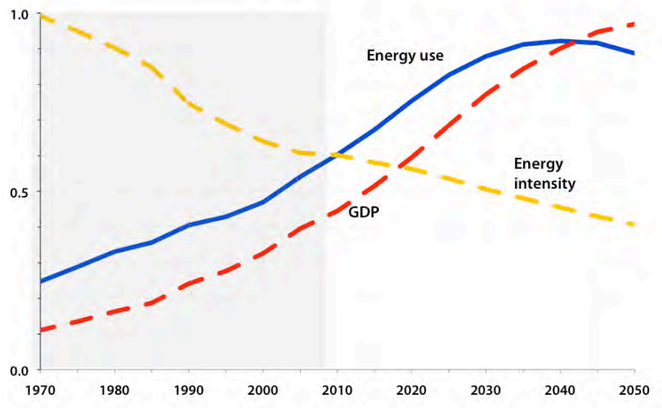

Figure 8: World total energy use, 1970–2050. Definition: Energy intensity = energy use divided by GDP. Scales: Energy use (0–20 billion tonnes of oil equivalent per year), GDP (0–150 trillion US$ per year); energy use per GDP (0–300 tonnes of oil equivalent per million US$).

The emerging water scarcity will come to an end once you put a price on irrigation water. Water will no longer be used in the wasteful ways that it is at the moment.

average will rise. This means that those who can afford it will eat better and better, while the poor will remain hungry, due to a lack of income. Of course, I don't like this, but this is what I foresee.

Future water

The next question that people typically ask is about irrigation water. My view is that the emerging scarcity will come to an end once you put a price on irrigation water. Water will no longer be used in the wasteful ways that it is at the moment, and desalination will enter the picture at even larger scale.

But won't that affect the price of food? Yes, it will affect the price of food. Does that mean that a lack of water for irrigation is going to lead to more starvation? Yes. But we would have starvation even if water remained as cheap as it is now. Starvation is the effect of skewed income distribution, not a physical lack of food.

Future energy

Once I have my forecast for future GDP, it is simple to make a forecast for energy use, based on the assumption that energy per unit of GDP – energy intensity, the yellow line – will continue its downwards trend, as shown in **Figure 8.** I forecast that the energy efficiency improvements we've seen over the past 40 years will continue. I assume that engineers will succeed in making cars, houses and industrial plants that use ever less energy per unit of output, so we'll continue the reduction in the amount of energy we use per dollar of GDP. To obtain future energy use (the blue line), I multiply my GDP forecast with future energy per GDP. This produces something interesting: the energy consumption of the world is going to peak around 2030 – very soon. When I die, the peak will roughly have been reached, and

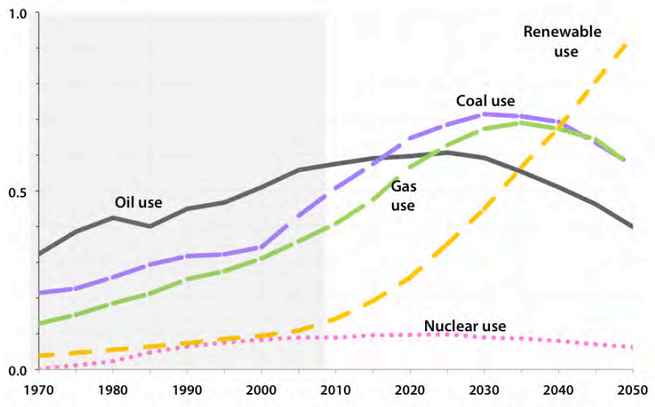

Figure 9: World energy use by type, 1970–2050. Scales: Energy uses (0–7 billion tonnes of oil equivalent per year).

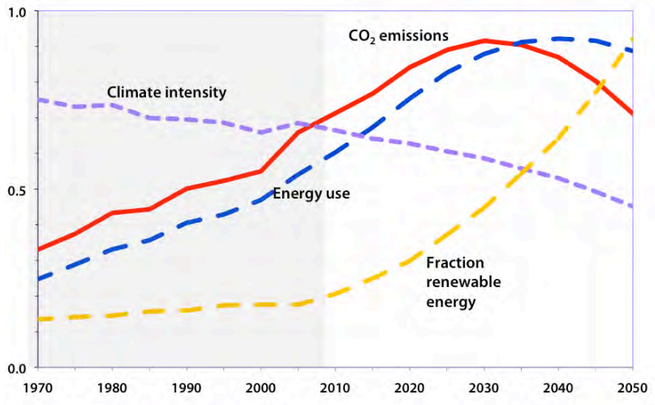

Figure 10: World $C0_2$ emissions from energy use, 1970–2050. Definition: Climate intensity = CO_2 emissions divided by total energy use. Scales: CO_2 emissions (0–45 billion tonnes of CO_2 per year); energy use (0–20 billion tonnes of oil equivalents per year); climate intensity (0–4 tonnes of CO_2 per tonne of oil equivalent); fraction renewable energy (0–40 per cent).

then the annual use of oil, coal, gas, and wind etc will start to decline. This follows directly from my forecasts of GDP and energy intensity.

Figure 9 shows what kind of energy sources we will be using: oil, coal gas, nuclear or renewables. Coal use will expand dramatically over the next 20 years. This is largely because of China and the big emerging economies. Total oil use – the sum of conventional oil and unconventional oil – is very close to its peak, as mentioned above. I think there will be a 20-year period of flat consumption before it declines. 'Peak oil' will occur, but not as a sharp peak.

Gas will increase dramatically, because this will be the cheapest and most politically expedient energy source in many industrialised countries like the UK and the US. Particularly in countries which tend to postpone difficult decisions, new generating capacity will not be built until there are brown-outs. When brown-outs are a fact, the fastest thing to do is to build new gas-powered utilities. They can be ordered and built within two years, and this is the backstop solution that is probably going to happen in the UK and in many other places. In the US, utilities running on shale gas are currently much cheaper than the nuclear alternative. This will accelerate the rapid shift to gas. Gas is better than coal because it emits one-third as much CO_2 per kilowatt-hour. Gas also has a beneficial future use as a back-up for intermittent sources like wind and solar, for when it's night or the wind doesn't blow.

I forecast a tremendous increase in the installed capacity of wind, solar and biomass energy, but in 2050 renewables will still only make up around 40 per cent of total energy consumption. In my forecast, nuclear faces decades of slow decline. By 2050 there will be few nuclear plants in the industrial world. Most of those plants are currently in the US and the UK, France, and Russia. Forty years down the line they will largely have moved to China, India, Pakistan and the big emerging economies.

Once I know future energy use, I multiply the use of each energy type with its CO_2 emissions per ton of oil equivalent. This gives me the central variable in international climate change negotiations: global CO_2 emissions per year. This is the red line in **Figure 10.** The right-hand part of Figure 10 is my forecast for what will come out of the ongoing negotiations, which, as far as I can understand, will go on for another 20 years with little result. You can see that CO_2 emissions will not peak in 2015, as is required to keep global warming below 2°C, but around 2030, and then decline fairly rapidly. Interestingly, emissions in 2050 will be more or less the same as they are today. The agreed UN goal is to halve 1990 emissions by 2050. My forecast is that we will not reach that goal.

Future temperatures

If you take my CO_2 forecast and you put it into one of the climate models, you can see how warm it's going to get in my future.

That's the red line in **Figure 11:** a rise in global temperatures of more than 2°C in 2050 relative to pre-industrial times. Out of curiosity, in my research I also looked further ahead: I assumed that CO_2 emissions will reach zero in 2100, by which time we will have phased out all use of coal, oil and gas. The climate model I used gave me a peak temperature of plus 2.8°C in 2080.

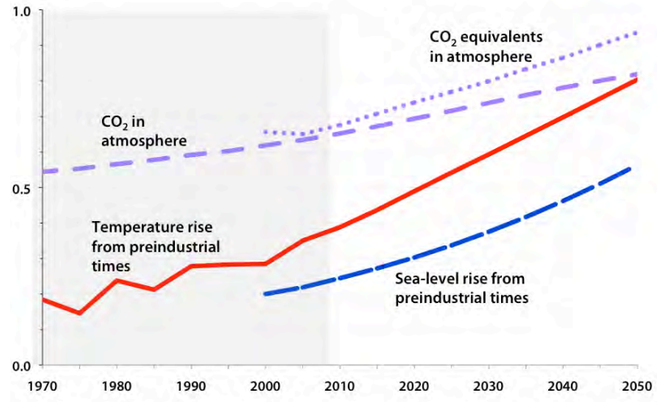

Figure 11: World climate change, 1970–2050. Scales: Temperature rise from pre-industrial times (0–2.5°C); sea level rise from pre-industrial times (0–1 metre); CO_2 in atmosphere (0–600 parts per million); CO_2 equivalent in atmosphere (0–6000 parts per million equivalent).

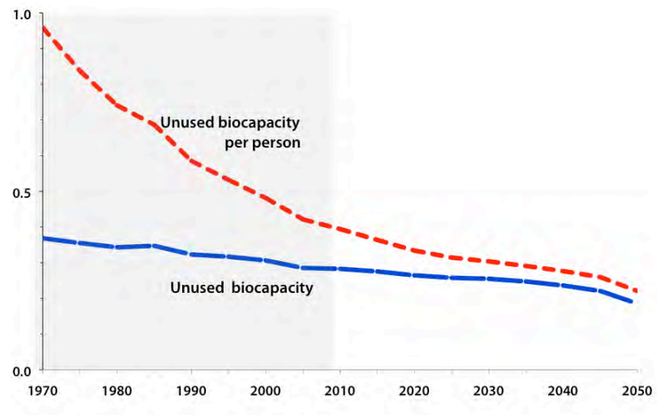

Figure 12: World biological capacity, 1970–2050. Scales: Unused biocapacity (0–12.5 billion global hectares); unused biocapacity per person (0–1.3 global hectares per person).

In free-market democracies it is unlikely that large-scale redistribution will happen in a peaceful manner. As a consequence, these societies will continue to strive for growth – but with less and less success.

We don't know for sure, but plus 2.8° may well be a problem. Global society has agreed that 2°C might be OK; plus 2.8°C might melt the Tundra and start self-reinforcing climate change. Oceans will continue to expand, and will be up another foot over these next 40 years.

Future wilderness

People like me love the wilderness, the forest and untouched nature. Will there be anything for us tree-huggers in the future?

In **Figure 12,** I've taken the unused biocapacity, the biologically productive areas of the world that are not being used for human purposes, and divided them by the number of people. This is my (very approximate) indicator for how much wilderness there will be for each of us. It's going down pretty rapidly, so in 2050, I am afraid there will be no real nature outside parks. Most untouched nature will be inside protected areas. Everything outside will either have been cut down or used for agriculture or urban areas.

We will also have the problem of rising temperatures, which will move the climate zones some five kilometres per year towards the poles: northwards in the northern hemisphere and southwards in the southern hemisphere. This means the ecosystems will escape the carefully-made national parks, which sit still. For me, the tree-hugger, this is very sad, but completely unstoppable. The only good thing is that most of the damage, the serious damage, has already occurred. Untouched forests have already been reduced dramatically in area, and coral reefs are already being bleached. Luckily I don't see any other

Rising temperatures will move the climate zones some five kilometres per year towards the poles. Ecosystems will escape the carefully-made national parks, which sit still. I don't see any huge, sudden biodiversity collapse, just the sad continuing impoverishment of all things natural.

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A mild crash with global limits

So, in sum I don't expect a global collapse within the next 40 years. The world will continue, more or less, its sad ways, building towards a climate crisis – which will not, however, reach full bloom until the second half of the 21st century. The world economy in 2050 will be much smaller than most people expect, and many will be less well-off than anticipated. This relative poverty will occur in two areas: in the rich world the majority will be poorer because we won't have much economic development over the next 40 years, and in the poorest parts of the world, there will be many poor because we won't have succeeded in lifting their incomes substantially.

Another effect of the smaller GDP is a beneficial one, namely that the ecological footprint of humanity will be smaller than it would otherwise have been. So, in many ways, we will not hit the resource ceiling and the pollution absorption capacity of the world with as high a speed as we once feared. The crash into global limitations will be further softened by rising investment to counter depletion, pollution and other ills. Thus, global society will, to some extent, be rational and start to meet the challenges; but this will limit growth in disposable income. Citizens of the rich world will not be very much richer in 2050 than today.

The root cause: short-termism

Personally I am saddened by this forecast, because it is so absolutely unnecessary. Global challenges could be solved if we only pulled ourselves together and decided to do something. This is particularly true for the climate problem. We already know the technologies that can cut greenhouse gas emissions sufficiently to avoid dangerous warming. These technologies are more expensive than the traditional solutions, but not very much so. It will only cost one or two per cent of GDP to make the shift to a climate-friendly future.

So why don't we do this? The root cause, as I see it, is the fact that human activity is dominated by short-term considerations. Neither the capitalist system nor democratic society appears to be willing to sacrifice short-term advantage in order to create a better life for our grandchildren. So my sad future will be imposed on us by our own decisions – which largely mean the pursuit of maximum short-term advantage. This short-termism is actually one of the reasons why it is intellectually possible to make a forecast for the next 40 years, because there is a certain stability in the decision-making structure that underlies all the important national and international action. For example, I think the short-termism of voters will stop politicians from agreeing on the type of regulation that could easily steer our capitalist markets to work for the social good – rather than only for maximum profit.

Bluntly speaking, short-termism in democracies and in capitalism will hinder a meaningful response. If we just decided to do something, it could easily be done. The problem is not a lack of technology, nor the economic cost, but the way we have chosen to organise our societal decision-making.

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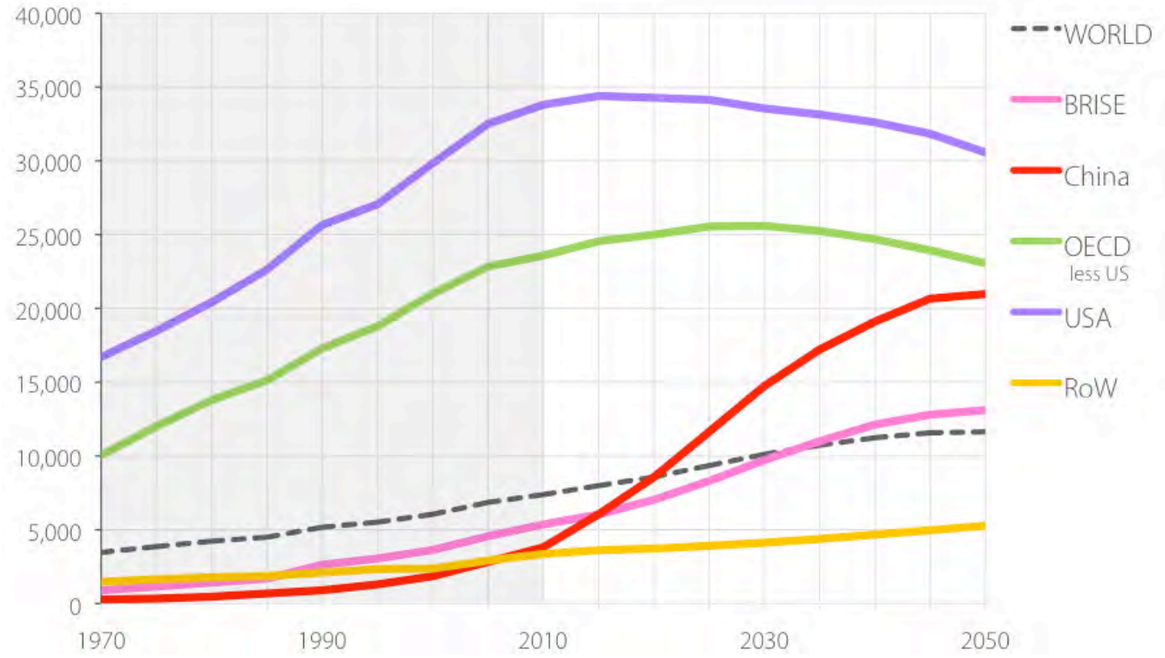


Figure 13: Consumption per person, 1970–2050 (in 2005 US$ purchasing power parity per person-year).

Regional futures

Finally, to make the forecast a little less abstract, **Figure 13** shows per capita disposable income (consumption per person) over the past and the next 40 years, for each of the five regions I use in my forecast. Let's start with the red curve, which is China. There will be a tremendous expansion in the income of ordinary Chinese people. Their per capita real disposable income will go up by a factor of about five. By 2050, the red line gets close to the green curve, which is OECD countries except the US. In this part of the industrial world (which includes the UK), disposable income will be more or less the same over the next 20 years. It will perhaps go up a little, and then go down a little. In practical terms, the typical Brit will have an endless feeling that the rent and the gas are always expensive.

The US is in a slightly worse situation, in my book, than the rest of the OECD. As far as I can understand, actual per capita disposable income in the US is already at its peak. It won't get higher, partly because the US economy is the world's most mature, partly because of the nation's huge debt, and partly because of the inability of the US government to make forceful and quick decisions on any issue involving the redistribution of income and wealth. I love the US, but I am afraid its decision-making ability won't improve within my lifetime.

Then, you have what I call 'BRISE': Brazil, Russia, India, South Africa and the ten largest emerging economies, including Thailand and Venezuela. Big things are about to occur there, and I predict they'll do a fairly good job over the next 40 years, doubling or perhaps trebling per capita incomes.

Finally there is the rest of the world, an eclectic mix of some 140 different nations, which I don't think is going to get very far in this period because of a continuing inability to achieve dramatic economic development – for various reasons. These countries will continue to experience slow growth over the next 40 years, as during the past 40.

Actual per capita disposable income in the US is already at its peak… partly because the US economy is the world's most mature, partly because of huge debt, and partly because of the inability of the US government to make forceful decisions on any issue involving the redistribution of income and wealth.

Individual perspectives

So is this good or bad? It depends on who you ask. In 2052, if you ask a Chinese peasant, who is by then living on the 36th floor in high rise number 115 in town 72, he will tell you that the past 40 years have been the most marvellous epoch in the history of China. He will say: "I have this wonderful apartment, I have a view, there's fresh air outside, I have the most unbelievable electronic entertainment, the gaming and the Internet and all. What else could anyone want? I can even, once in a lifetime, go to Rome, although it's very crowded." So from a Chinese peasant's point of view the next 40 years is going to be great.

Then you can ask someone in the manufacturing sector in middle America. If I go there and ask about quality of life today, he says, "I haven't had a raise since 1980." The real disposable income for automobile workers in the US has essentially been constant for 30 years. Workers have not had a raise; the élite has taken almost all of the new added value in the country. If I go and visit the same autoworker 40 years down the line, he will say, "The past 40 years have been endless hell. I am worse off now than I was 40 years ago. My children didn't have as good life as I had in the 1990s. They couldn't buy a decent house in 2010, and have been living in rental." So from the US autoworker you will get a totally, dramatically, opposite story to that of the Chinese peasant.

What do I think a UK office worker is going to say in 2050? Her real disposable income will be essentially the same as it is today, with no real change in the goods and services which she can buy for her money. That means that 40 years down the line, the feeling will be one of stagnation: it has been the same all along, it is still expensive to pay the rent, it is still expensive to get hold of the fuel for your car.

And there will be two new irritating elements. First whenever you take your vacation in the Mediterranean, the Canary Island or Spain, there are these hordes of Chinese and Indians! And second you will hear people say: "Where did all that cheap clothing go? You know, all those cheap goods; everything was so cheap in 2010. You could get a heater and cooker and washing machine for nothing!"

The reason, of course, is that the Chinese, who currently produce these things for us at ridiculously low prices, will by then be five times richer and will only produce expensive stuff. You might ask, why couldn't we get cheap things from those other places that are still poor in 2052? We could, if we managed to engineer economic development in those countries; but I don't think we will.

What to do?

So what should we do about this sad story?

First, have fewer children, and that's particularly important when you're rich. My daughter, who is 29 and Norwegian, is the most dangerous animal on the surface of the Earth. She consumes between 10–30 times as many resources and generates 10–30 times as much pollution as an Indian child. So, it's much more important to have one less rich kid than it is to have 10–30 fewer Indians. I'm serious. Population control in the rich world should be the prime focus.

Secondly, reduce your CO_2 footprint. Don't drive big cars, don't drive them so far, don't fly so long, and insulate your home.

You might ask, why can't we get cheap things from those other places that are still poor in 2052? We could, if we managed to engineer economic development in those countries; but I don't think we will.

We don't have strong government... or, to be exact, we don't have support for strong government. Civilised, solution-oriented citizens ought to be in favour of collective action.

Third, support strong government. As mentioned above, most of the solutions to today's global problems exist, and the only reason they're not implemented is that we don't have strong government. Or to be exact, we don't have *support* for strong government. Thus civilised, solution-oriented citizens ought to be in favour of collective action. I think we will see 40 years down the line that it was the Chinese who did, in the end, solve the climate problem for us – through collective action. They will produce the electric cars and the technologies we will need, and they will implement them in China through centralised decisions. Meanwhile, we will be fiddling around with half-baked quota systems that provide insufficient incentives – which might modify development somewhat, but doesn't solve the problem.

And then, fourth and finally, if we want to help the world's poor, we (the rich) should build and pay for a complete clean energy infrastructure in the poor world. This would ensure that they don't have to build a cheaper, carbon-intensive energy system for the energy they sorely need: electricity, fuel and heat. If we did nothing else, that would solve a substantial part of the future climate and poverty problem.

That, my friends, is what I see. I don't like it... but still, feel free to shoot the messenger.

In 2010 the artist Chris Wainwright journeyed with Cape Farewell on an art and science expedition to the High Arctic. Struck by the light against the quickly changing landscape, he used semaphore, the tool of last resort for lost travellers, to spell out his amazement and concern: *"Here comes the sun, there goes the ice"*.

Living on a finite planet

(where no-one likes to hear bad news)

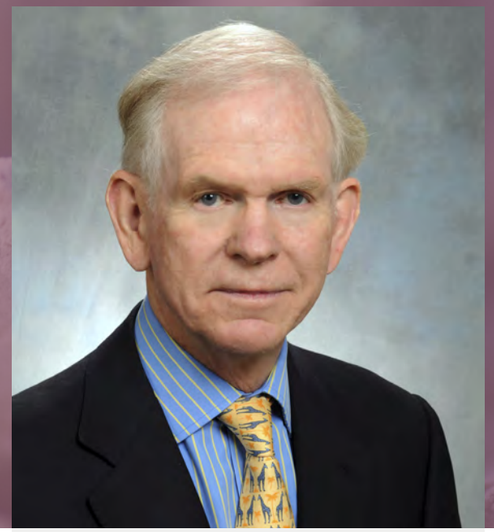
Jeremy Grantham

In the winter of 2008, ceramicist Clare Twomey planted 8,000 exquisite, hand-made, and unfired china clay flowers at the Eden Project site. Over time, they weathered and dissolved, eventually returning to the clay earth surrounding them.

Living on a finite planet

(where no-one likes to hear bad news)

Jeremy Grantham



We're going through one of those very rare things indeed: a paradigm shift. Having spent the past 200 years with the prices for everything declining, around 2002 this shifted, and the price of almost everything started going up. In 10 years, without much fuss, we've given back all the price declines of the previous 100 years. That's quite a remarkable shift.

The reasons are brutally simple: the growth rate of the population, and the amazing economic growth in China and India.

We have a problem with energy, which I think we'll stagger through, though it will require a lot of painful shifts and demand a lot of extra capital to maintain any growth for the next 20–30 years. We'll have an even bigger problem with metals, which are very precious, scarce resources which we have been chewing through. It could be as little as 30–70 years until we run out, though for the foreseeable future, I think we'll muddle through, moving to iron and aluminium which are more common.

Jeremy Grantham is a co-founder of GMO LLC, a Boston investment management firm where he is chief investment strategist, a member of the board, an active member of the asset allocation division and the author of a quarterly letter to clients. In 1998 Jeremy and his wife Hannelore established the Grantham Foundation for the Protection of the Environment, which distributes grants focusing on climate change and biodiversity conservation, with an emphasis on international initiatives. Key funding programmes include the establishment of research institutes and LSE and Imperial College in London, and a centre at the Indian Institute of Science in Bangalore. Jeremy is also a trustee of the Nature Conservancy. Jeremy holds degrees from the University of Sheffield and Harvard Business School.

This article is adapted from a lecture given in Cambridge, in April 2012, at The Prince of Wales's Business & Sustainability Programme.

The problem is, capitalism can't handle shortages. There is no economic model, according to the OECD, that takes the finiteness of resources into account.

The real problem, however, is feeding ourselves. There are four critical parameters to bear in mind: water, soil, phosphorous, and potassium. Without any one of these, you can grow nothing at all. So, you can have as much soil as you want, but if you have no potassium you get nothing; you can have as much water as you want, etc. All four of these are limiting factors, and we'll use them up. The two most dangerous ones, in my opinion, are the less obvious ones: potassium and phosphorous.

The quantity of capital that's being sucked in to keep the resource machine grinding is reducing the ability of the world to grow. Here's a concrete example: we used to have a very low-cost barrel of Saudi oil. We're replacing that now with an incredibly high-cost, offshore Brazilian barrel. The service that the barrel supplies is identical, but the cost of extracting it is dramatically different: it now requires many more people and much more capital. This is being played out for every resource everywhere. Copper ore, in the dim, distant past, produced about 8 or 9 per cent copper. In the fairly distant past, 50 years ago, it was 2 per cent, and now they mine, on average, about 0.5 per cent of copper from the ore. So, you have to handle four times as many tons of ore with energy costs that have tripled in the fairly recent past, which means 12 times the energy input for copper.

These sorts of costs play around the system, and so the growth rate of the world has started to slow, very noticeably for the developed world and not so noticeably for the emerging world – yet. But as the developed world slows down, so developing countries will lose their head of steam. The drop in the growth rate of the developed world has been camouflaged first by the huge housing bubble in US and Europe, and then by the bust of 2007–08, both of which make it seem temporary. But under the surface, the GDP growth rate of the OECD block started to decline from about 1995 onwards.

Until then, the growth rate of the US was like a battleship. It grew at 3.4 per cent from 1895 to 1995, and even the Great Depression bounced off it; afterwards, it was as if it had never occurred. And two-thirds of the time, the growth rate remained within 1 per cent of its long-term trend; it was incredibly stable until 1995, when it began to slope off, and there has been nothing like that in modern times. By the time we get to late '07, even before the financial crash, the draw-down is 13–14 per cent from the old trend. I think the US will be lucky to achieve much more than 1.7 per cent going forward – maybe, if it's really lucky for 20 years, up to 2 per cent.

To go from 3.4 to 1.7 per cent growth in 15 years is a dramatic down-shifting. It's quite remarkable. It hasn't been talked about, any more than the rise in the price of commodities and the overall paradigm shift has been talked about much. But it's beginning to be talked about.

The problem is, capitalism can't handle shortages. There is no economic model, according to the OECD, that takes the finiteness of resources into account. Economists just assume; they reach out and take what is necessary, simple supply and demand. But it just ain't so. We live in a finite world and we've got to start thinking about developing alternative models that recognise that that is the case.

Human nature and vested interests

I've become an expert in financial bubbles. Bubbles have a long and honourable history, and they have one thing in common: no-one ever learns. They demonstrate, to a remarkable degree, our touching faith that somehow everything will always be fine.

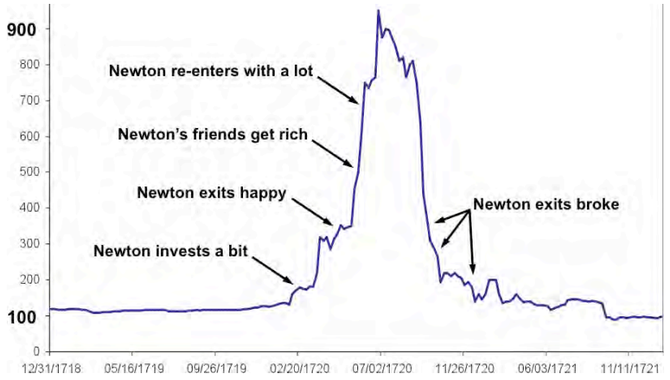


Figure 1: Isaac Newton's Nightmare. South Sea Stock, December 1718 – December 1721. Source: Marc Faber, editor and publisher of 'The Gloom, Boom & Doom Report' www.gloomboomdoom.com

The South Sea Bubble involved selling an annuity with a mathematical value, and it plays a special role in the heart of bubble experts. Fairly early on, Isaac Newton decided he would buy it. He thought it was a little cheap and might go up, and he made some good money and got out happy. And then he had this terrible experience of watching all his friends get rich. Finally his nerves cracked, and he got back in, with all his profits, plus he borrowed some money. He exited broke. You can see the story in **Figure 1.** This was a serious financial setback for him.

Newton said, "I know much about the movement of heavenly bodies, but little about human nature." One of the public letter-writers of the time, using the pen-name Cato, said after the bust that "there must be a plentiful supply of stupidity in human nature, else man would not be caught, as he is, a thousand times in the same snare… and even while reeling from the wounds, he is preparing to do it again." I was really feeling proud of myself that I'd rumbled this truth about 20 years ago, only to discover that it was old hat in 1721!

It's not just that people want to believe good news. We're an optimistic species, but we're being egged on by powerful vested interests, always telling us that things are normal when they know better.

Anyone who knows anything knows that humans just assume the best, bubble away, and get crushed. No-one ever learns from other people's experience, and so we just carry on, with the recent example of the housing bubble in the US in 2007 precipitating the global financial crisis.

The finance industry knows about bubbles. It knew 'dotcom' in 2000 was a glorious example of a bubble, but it encouraged everyone to play along. It is so much more profitable to have a bubble than to have a boring market! The American market grows at 1.8 per cent, and at that rate, everyone dies of boredom; no-one makes a fortune. Much better to have it soar up and triple in four years, and then collapse. Then the smart people make a killing on the way up, save a decent fraction of their money on the way down, and come out far ahead.

So it's not just that people want to believe good news. They'd have bubbles without Goldman Sachs, they'd have bubbles without the finance industry; we're an optimistic species. But we're being egged on by powerful vested interests, always telling us that things are normal when they know better. Believe me, no financial advisor will ever tell you what is really the safest thing to do with your money. They're all covering their tails. They're investing to keep their job, not to keep your money. In a choice between protecting your job or your clients' money, it's no contest.

In climate change, we have the same thing. We have the energy industry – the only other vested interest as powerful as that of the financial world – egging people on to be confused about the issues. They do it very successfully, with foundations with misleading names, think-tanks like the Cato Institute and the Hudson Institute, whose job in life appears to be propagandise anything and everything that is useful for energy interests.

So, firstly, people want to believe that the climate change stuff is hocus pocus – they want to believe that everything will work out and we can grow and our children can get rich. Secondly, they are egged on by vested interest.

Why do these people work so hard to mislead us? It seems to me that either they don't have any grandchildren, or if they do, they're planning to make so much money that their grandchildren will be okay. They do it in the face of the most amazingly simple, straightforward data. One of my favourite examples is the melting of northern sea ice. Nowadays you can get through the Northwest Passage, where so many Brits froze to death in the 17th and 18th centuries. Thirty-six commercial ships have now sailed around the Russian coast; four years ago, no commercial ship had ever sailed that way. How is this possible without systematic climate change?

And yet, no Republican could get elected if he admitted that the climate was getting warmer.

Bubbles and beyond

Here's the story of how I arrived at the conclusion of a paradigm shift. **Figure 2** is twelve of the most famous bubbles. We're specialists in this, and we put this together in a desperate attempt to explain to our clients in this latest bubble that we could expect it to break. This was widely thought to be a new golden era; Greenspan kept telling us it was, and our clients, for the first time ever, really believed it. We manage money for every Ivy League school, and most of the members of most of our committees – the committees of all the august universities – believed that this time something was different.

When we said it was just another bubble they thought we'd lost the plot. We kept

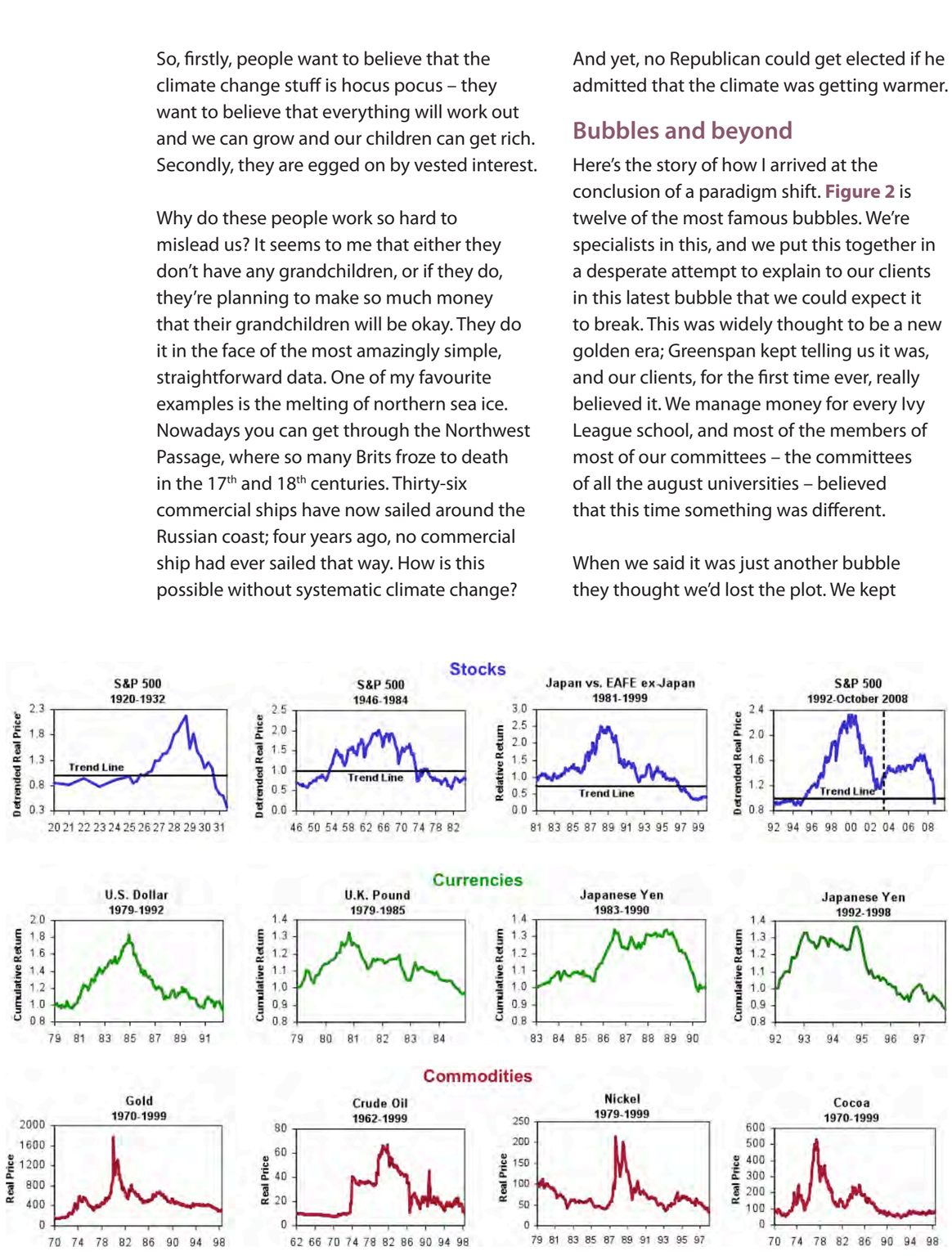


Figure 2: All Bubbles Break. For S&P charts, trend is 2 per cent real price appreciation per year. Source: GMO. Data through 10 October 2008.
* Detrended Real Price is the price index divided by CPI + 2 per cent, since the long-term trend increase in the price of the S&P 500 has been on the order of 2 per cent real.

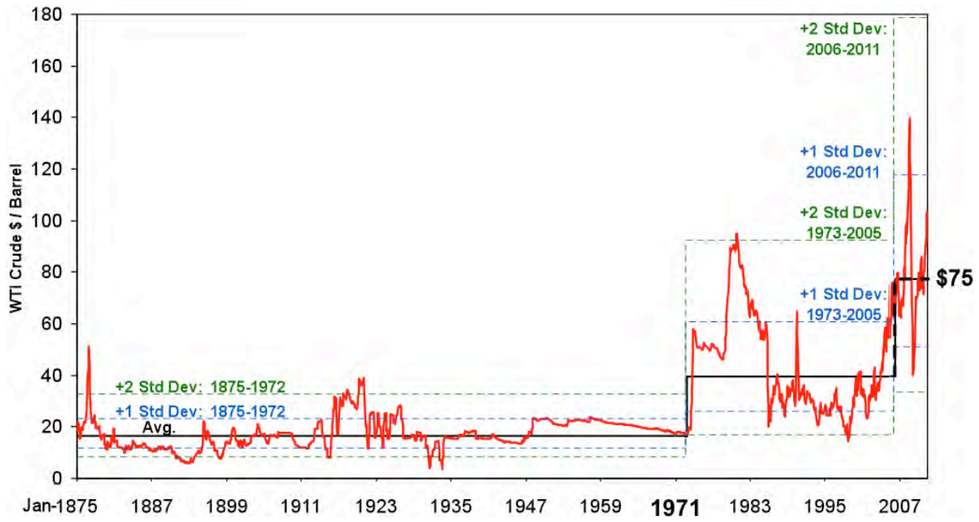


Figure 3: At last, a paradigm shift. All oil prices in 2010 dollars. Source: Global Financial Data, GMO, as of 31 March 2011.

getting fired; in the asset allocation group, to which I belong, we lost 60 per cent of our book of business in two-and-a-half years. No-one has ever lost that kind of money, before or after, but we did, because we were shouting the bad news that it was financially irresponsible, that it would all come to rack and ruin. The other people who believed as we did were hiding under the table keeping their mouths shut; that turned out to be a pretty good strategy, because we were getting fired from accounts that were doing fine.

We have a big array of products, and even where they were doing OK they were firing us because they just didn't want us in their building. It was amazing how people wanted to believe. (Fortunately, we have now gained a reputation for thought leadership. Clients actually like to deal with firms that are thinking about the distant future and what issues they should be beginning to grapple with, with plenty of lead-in time.)

Now, let me just point out that at the top, in 2000, prices were 35 times earnings. In 1929 and 1965 they had been at 21 times earnings. So, 21 was the very, very peak of the great bubbles until now, and this one was at 35, and yet everyone wanted to believe that somehow something had happened to justify a loony price. It was two-and-a-half times replacement cost, so if you had a dollar of an asset, it became worth $2.5.

In the process of arguing that this would not work, we studied bubbles everywhere, and then crude oil caught our attention. We slapped crude oil into our list of bubbles very happily at first. Yet another bubble; certainly not a paradigm shift. A few more years went by and this nagged at my subconscious, and I began to realise that it was not quite what it appeared to be, and that we were misrepresenting the data.

Let's look at the price of oil for 100 years **(Figure 3).** You would expect normal price volatility to cause occasional and fairly regular spikes, around every 44 years. This is true even for a very volatile commodity like oil, which had a stable average price of $16 a barrel. The normal volatility of oil is more than a double, less than a half, so what people don't realise is that this means the price will fairly routinely go to $35–37 a barrel, yet can still drop down to $16 again.

Onshore, conventional oil peaked in the late 1970s. Increasingly deep, dangerous, expensive offshore oil has kept production increasing, but it's still slowing down. Since 1982, we've never come close to finding as much oil as we produce.

After the crisis in 1973–4, OPEC intervened and shifted the average price to $36. According to the same mathematical trend for volatility, this meant the price could now be reasonably expected to jump to $80, and it could still go back to $16 at any point. This continues for the next 30 years. This was what allowed me to say it was just part of the old trend – a temporary shock with a stable average price.

But, actually, of course, it's not. What had happened was that a cartel was now manipulating the price and had reset the average price per barrel permanently – the first real paradigm shift. Then, in 2007, the price jumps again, making me think that the average price has risen once more. The other day I was speaking to the second-in-command at Shell, and he said he thought a reasonable price of oil per barrel was $75–85. Bear in mind, if the average cost per barrel is $75, the price can jump to $170; and it can go back, too, for a second or two, to $30–35. We've seen this since 2007, backing up this idea that the average price has risen again permanently.

Recently, we've had a little pick-up in oil production, probably because of fracking; but we can expect it to decline again soon. Onshore, conventional oil peaked in the late 1970s. Increasingly deep, dangerous, expensive offshore oil, and 'secondary' and 'tertiary' oil from depleted fields, has kept production increasing, but it's still slowing down; it has done so for the past 30 years. Since 1982, we've never come close to finding as much oil as we produce.

This is a different world from the one we all grew up in, where every commodity was declining in price, except for oil, which was flat. After I spotted this change in the average price of oil, I began to think, is this the only commodity this is happening to? What about metals, and so on?

Figure 4 shows GMO's calculation of the price of 33 equally weighted commodities since 1900. Prices come down and then spike for World War I – why wouldn't they? – and then you can see the impact of the

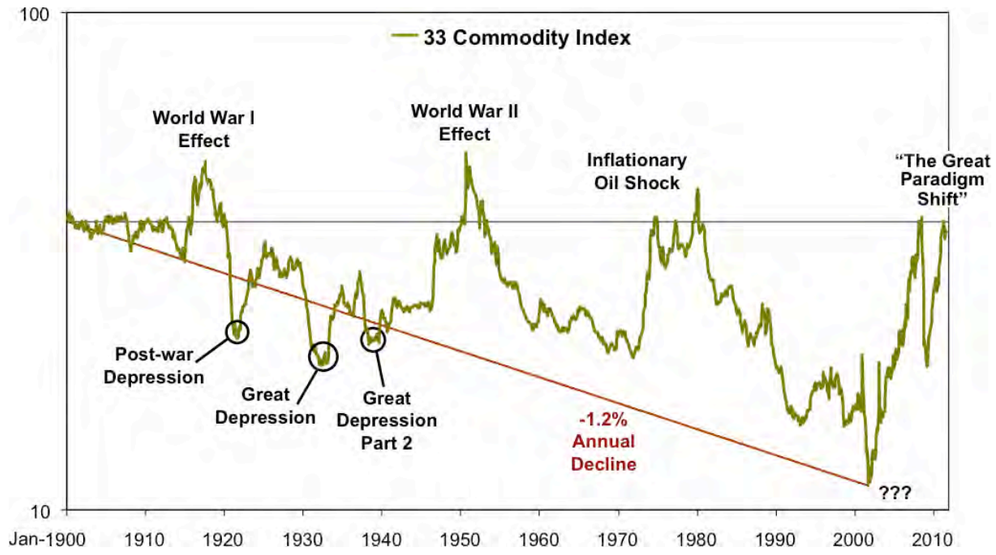


Figure 4: GMO Commodity Index – the great paradigm shift. Comprised of 33 commodities equally weighted at initiation. Source: GMO. As of 31 August 2011.

Post-war Depression, the Great Depression, the Great Depression Part Two, World War II, and the inflationary oil shocks of '74 and '79. In between, the price always wants to go down whenever it has a chance; that was a 1.2 per cent a year decline in real terms. Cumulatively, the price of a typical commodity declined by 70 per cent in real terms over 100 years – a dramatic help for getting wealthy, and that is what it's helped us to do.

Then, since 2002, prices have gone all the way back up. It's a remarkable event. So, I'm not giving a terrible forecast here. I'm saying we have had a shift. We live in a different world – a world where you expect one thing, and you get the opposite. We have given all the price reductions of the 20th century back.

What are the odds?

Then we started to get into crazy, mad details; by now we knew we had something pretty unusual and so we decided to analyse it as we did all our bubbles. We asked, "What are the probabilities that iron ore, which is incredibly far from its average price (4.9 standard deviations), is on its original trend, and it's just having a bubble?" The answer was that there's a 1 in 2.2 million chance that this is in any way 'normal'. We have never seen anything like that in the stock market. That is hugely unlikely.

	Standard deviations from average price	Probability
Iron Ore	4.9	1 in 2,200,000
Coal	4.1	1 in 48,000
Copper	3.9	1 in 17,000
Corn	3.8	1 in 14,000
Silver	3.7	1 in 9,300
Sorghum	3.5	1 in 4,300
Palladium	3.4	1 in 3,000
Rubber	3.3	1 in 2,100
Flaxseed	3.3	1 in 2,100
Palm Oil	3.2	1 in 1,500
Soybeans	3.1	1 in 1,000
Coconut Oil	3.0	1 in 740
Nickel	2.7	1 in 290
Gold	2.6	1 in 210
Oil	2.5	1 in 160
Sugar	2.5	1 in 160
Platinum	2.4	1 in 120
Lead	2.4	1 in 120
Wheat	2.4	1 in 120
Coffee	2.3	1 in 85
Diammonium Phosphate	2.1	1 in 56
Jute	2.1	1 in 56
Cotton	2.0	1 in 44
Uranium	1.9	1 in 35
Tin	1.9	1 in 35
Zinc	1.9	1 in 35
Potash	1.9	1 in 35
Wool	1.7	1 in 22
Aluminium	1.4	1 in 12
Lard	0.9	1 in 5
Pepper	0.5	1 in 3
Natural Gas	0.2	1 in 2
Plywood	-0.1	1 in 2
Beef	-0.1	1 in 2
Cocoa	-0.1	1 in 2
Tobacco	-3.3	1 in 2000

Arbitrary Bubble Cut-off

Figure 5: The mother of all paradigm shifts. Probability: implied probability under assumption of normal distribution of valuations. Arbitrary bubble cut-off: probability of representing a new trend. Source: GMO. As of 28 February 2011.

I'm saying we have had a shift. We live in a different world – a world where you expect one thing, and you get the opposite. We have given all the price reductions of the 20th century back.

We saw this again and again, for a large number of commodities (see **Figure 5**). The standard cut-off point for calculating whether prices are fluctuating normally is for them to sit within two 'standard deviations' of the average price. Even the four important commodities of uranium, tin, potash, zinc are at 1.9 standard deviations, right on the cusp of what we would say is a bubble. There's only a 1 in 35 chance that what's happening to their prices is a 'usual' bubble rather than a permanent rise.

What is the probability that so many of these commodities are 'bubbling' at the same time? What are the chances that this is not a giant commodity paradigm shift? Statistically, the answer is nil. There is no chance.

This just speaks for itself. It says: we live in a different world, wake up! And I think we're going to be able to say the same for growth rate. The developed world has simply slowed down. What is the effect of halving our growth rate in 15 years? What industries will it bear down on most heavily? What will it do for the aspirations of politicians who are constantly aiming for growth, far in excess of any possibility?

So what's caused it?

There are two reasons for the paradigm shift, as I see it: the rise in world population, and the role of China. When Malthus was born, there were a billion people on the Earth; when I was born, there were about 2.2 billion, and this has tripled in my lifetime. I've become a Malthusian after my work on bubbles; his 'Essay on the Principles of Population' simply makes the point that any animal species has a huge redundancy in its capability in growing its population. So, if you produce a huge harvest and leave it lying around, the mice population will run amok; and if there are lots of mice, the fox population will explode too. And then when they have eaten up all the corn, they will implode. This has been going on for every animal species on the planet for a long time.

Mankind spent two million years living with its nose pushed up against the boundary of food. Five good harvests in a row, and people had lots of children. Five bad harvests in a row, the children died, and no children were born. That's how it was. Malthus said this was the law of nature, we'd better get used to it.

Just as the ink was drying on that report, ironically enough, coal was being dug up in Yorkshire and we were off on the Industrial Revolution; that was followed by oil and gas and so on – the hydrocarbon revolution.

A gallon of gasoline will buy you 300 hours of human labour. Hydrocarbons are prodigiously powerful: they meant that everyone had, for a few dollars, resources at their fingertips that only kings could have had in 1200. This allowed for a huge increase in wealth, science, everything – among other things, the science of growing food.

As time went by, we used the intensity of hydrocarbons to force-feed agriculture, which became a way of turning oil into food: tractors, farm machinery, delivery costs and fertiliser. It's a 250-year reprieve. From about 1800 to about 2050, we have had this hydrocarbon holiday. It's an unbelievable resource that was given to the planet, just once, and we have used it up without any regard to its preciousness.

There's a reason for this: we can't price a resource. Capitalism cannot price for finiteness. It's short-term supply and demand – or total ignorance. Anyone who is reasonable knows

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that this is wrong: you know that you're getting through this precious resource, chewing it all up, and there should be some consequence. Yet there is not. There is no way of accounting for the fact that we have something now, but we will not have it in the future. It isn't an easy thing to deal with, I will concede that. Capitalism simply does not have the tools.

So, you take a population at 1 billion that was doubling every 1,000 years, and you raise it, in a single lifetime, from 2 billion to 7 billion, on its way to 10 billion. The other factor is China. Last year, China used 53 per cent of every bag of cement used on the planet, 48 per cent of all the iron ore and 47 per cent of all the coal. And these are important things, coal and iron ore. If China wanted to double its economy in 10 years (which is slower than its growth rate today, or over the past 20 years), the coal production of the world has to go up by 47 per cent. That's just to take care of China – forget India, forget everywhere else.

You can't do it. The reserves are substantial, but there are higher costs all the time; and it's not just that the cost is going up. The resources required to get the commodities is going up, as I said, and as the resources go up, it squeezes the rest of the economy. This is happening already and not being noticed.

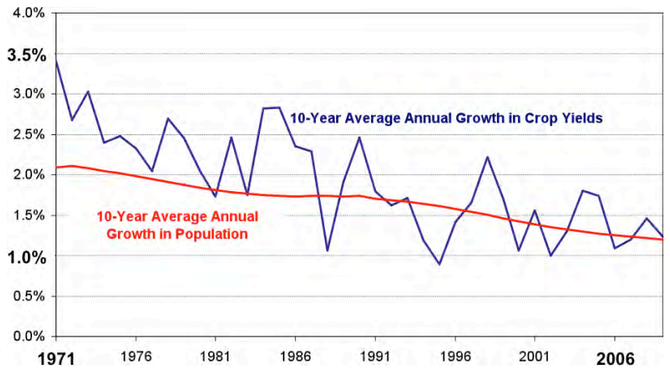

Figure 6: Ten–year average annual growth in crop yields and population. Source: Food and Agriculture Organisation of the United Nations. As of 31 December 2009.

The real challenge

Now, I think we'll muddle through with water – it's a watery planet, and though we waste amazing quantities, water recycles unimaginably effectively. We'll get by with metals; in the long term they will come back to haunt us, admittedly, but we'll muddle through for a long, long time. But food is a problem.

In the agricultural revolution, we've increased the input of fertiliser by five times, in China by seven times. Every kilometre has five to seven times more input of agricultural resource. Yet with intensive farming, the output declines over time because the soil degrades **(Figure 6).** During the Green Revolution, productivity per acre was a stunning 3.5 per cent a year. This has declined, erratically, to 1.2 – still a magnificent number, but the trouble is that the red line, the global population growth, is also 1.2 per cent. We are increasing productivity per acre at exactly the same speed that we are increasing the human population. If we want to eat meat, this will break the bank. We have to increase productivity and we have to get population growth down. Otherwise, we have a crisis, fairly immediately.

People simply do not get the point that you can't have 'sustainable growth' forever. You can have sustainability forever, or growth for a few years. But you cannot have sustainable growth, in the sense of physical growth, for any extended period of time. A favourite illustration of mine is Ancient Egypt, which had the longest-lived civilisation, lasting from about 3500 BC to 500 AD. They had the same religion, the same Pharaohs, the same laws, the same culture, the same language. Let's imagine they started with 1m^3 of physical possessions, and their economy grew at the rate that the global economy grew in 2006 and 2007 – 4.5 per cent GDP growth globally. If they keep that up, after 3,000 years what do you do with your physical possessions? They fill one billion solar systems.

We have no more land. We used to have a New World; we used to have the Midwest, we used to have the Ukraine. We have used them all up.

What about population growth of 1 per cent, a derisory rate? They had two million people, so after 3,000 years, their population would have grown by seven trillion times two million. You cannot grow at 1 per cent: nowhere to park people, nowhere to park physical possessions. How about 0.1 per cent population growth? 0.1 for 3,000 years is about a 20-fold increase in population. In fact, Egypt's population actually doubled, maybe tripled. Even 0.1 per cent cannot be sustained.

So, you can't have 'sustainable growth'. We have to change the system.

A crisis in arable land

Potash and phosphate, potassium and phosphorous are, as I said, limiting factors. Without them you can grow nothing. They are elements: you cannot make them, you cannot substitute for them. They are unwilling to negotiate. They are absolutes, in a world with few absolutes; and we mine them, for heaven's sake! In other words, we go into a dried-up ocean and take these conveniently concentrated, wonderful, high-grade phosphorous reserves; we dump them in a truck; and we ship them around the world. And the same with potash. We have 280 years of reserves if we don't grow, 116 years if we do grow. But 80 per cent of potash is stuck in Canada and Russia. America is okay; we have Canada, we can invade them, we can negotiate with them… but the UK might be in more trouble. Yorkshire recently had a very big potash discovery 20 kilometres under the North Sea. I am suggesting to the new Governor of Yorkshire to put up a tariff wall and not trade the stuff easily!

Very quickly, you will find that food and fertiliser is treated differently. In 2008, the Russian Government overrode all contracts and said they couldn't export wheat. China, the year before last, said they couldn't export potash, and the WTO got in there and wrestled with them. And this year India tried to ban the export of cotton. So the world is already getting to the point where agricultural products are being banned from export all over the place; this is not a distant prediction, this is already underway. The world is beginning to react differently to these precious resources. The worst of all, and nearly a certain crisis, is phosphorous. Everyone knows about this but no-one is interested. Phosphorous is all owned by Morocco and the Western Sahara; 85 per cent of everything we know of high quality is in Morocco, which makes Saudi Arabian oil look like a two-bit player. This is much more serious.

In the end, eating is more important than heating. The only way will be to change the style of farming, and I think it's a central issue before us, the one that bites the first. Soil erosion would be worse, except it turns out that ending coal farming takes away erosion as a serious problem. But we're just running through phosphorous.

When we've used it up, we'll have to recycle. We will be back in the Middle Ages where all your cow manure and all your rotten veggies have to go back on the field, because your life depends on it. Even in the late 19th century there was periodic starvation in Eastern Europe; their soils were reaching the phosphorous limit. We can't support anything like 10 billion people with these techniques. We have no more land.

We used to have a New World; we used to have the Midwest, we used to have the Ukraine. We have used them all up. Now, we have a global system, where everything is being used. We have a hard time bringing in enough land to offset the areas taken up by new Chinese and other Third World cities. They're all built in river valleys, so they're taking prime agricultural land and we're replacing it as best we can. There has been no material increase in the land available for agriculture for a long time. One-third of our arable land, since the beginning of time

10,000 years ago, has been turned into rubble – desert and rock that is totally irretrievable. One-third. In the past century we have been going through our soil at 1 per cent a year. You can work out how quickly that goes.

Resources, not climate change

Climate change is not the most important problem for humans: these resources are. And the most important part of climate change, for us, is how it intersects with growth. In 2100, the most optimistic assessment is that the output for grain will be down by a third, and the more pessimistic ones over two-thirds. You can work out what a terrible situation that is. So, we're recommending to people to get a good farm, and a good farmer.

Also, saving resources in the world that I am describing is going to be massive. Anyone who can steer their firm into doing more of that, or steer their investments into holding more resources, is going to do well. It's hard to persuade people to invest in order to win in the long run, when they won't know whether they will win next year. People like to think they have a higher probability of making a bet that will win next year. But if the certainties are higher out of the long horizon, that's what you should do.

Back to farming. In most areas, except for northern latitudes like the UK, you can end up with more output per acre if you use organic farming, and this requires a very, very small fraction of the inputs, particularly phosphorous. If we use only organic farming in 50 years, we'll be able to preserve phosphorous reserves for another 500 years and, in that time, gracefully get our population down to the level that is necessary – perhaps a billion people, perhaps even 500 million. But, if we maintain 1.7 per cent GDP growth for 500 years, we're going to come up against hard limits. Gradual population decrease is not painful; in the developed world we're already on that kind of flight-path. But while the overall world population is still growing, the shock to the system is going to be severe.

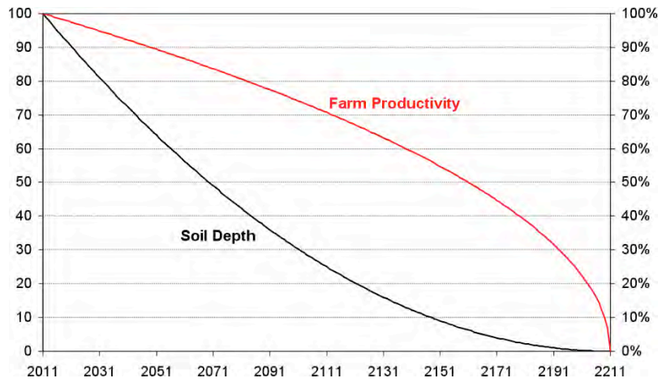

Figure 7: The Devil and the Farmer. The Devil's deal represents culmulative soil and productivity loss. Scales: Soil depth (inches); farm productivity (percentage of original level).

Here's my illustration of the limits of capitalism **(Figure 7).** The Devil comes to a farmer and offers him a contract for 40 years, saying, "I will triple your profits, but in return you will lose 1 per cent of your soil." This is the deal that modern farming makes: about 1 per cent of soil is lost, which is about 10–100 times faster than it can be replaced naturally. Organic farming will replace it, but every capitalist signs the contract, because the tripling of your profits is massively more than any hit to your productivity in that first 40 years. The farmer and all his neighbours re-sign for another 40 years – it's an easy corporate decision again – and then for the third, the fourth and the fifth 40 years. It's still no contest. But at the end of 200 years, there's no soil and no food.

When the starving mob arrives, the good news for the farmer is that he dies a rich man: he's made a fortune. There is nothing, as yet, in the corporate mentality, or methodology, or discount rate structure, that would make it anything but a crazy decision not to sign each contract with the Devil.

You cannot count on corporations to get this job done. You can count on individuals to drag a whole corporation with them for a critical 10–15 years, sometimes, and it's hugely helpful, particularly if they can twist the arms of politicians. But this is a governmental issue; we must have governmental leadership, rules and regulations. The only people looking forward at the soil erosion problem at the moment are the Chinese government. They can deal with long horizons, they have a Confucianist background for thinking long-term, they're not getting re-elected every two years, they hold all the cards and they are thinking ahead. They are worried about resources.

The capitalist model has to change, even if only little by little. The heavy lifting has to be done by government; and everyone who can help should move the government. They're very sensitive to corporations; they'll probably listen to you. In the end, we're all dependent on sensible government, and that's pretty scarce. Often, they wait until there's a crisis and then they jump.

A final picture

I want to talk about Egypt one more time. Egypt had a population of 2 million when Napoleon invaded; it has 82 million today, and it's going to rise to 120 million. It can feed about 60 million. Egypt used to feed the Roman Empire; without Egypt, the Romans would have collapsed long before they did. Egypt has been the world's bread-basket for ever, and still today it has some of the most productive acres on the planet. But it can only feed 60 million people, and it buys the rest by selling the oil it was lucky enough to find.

You cannot count on corporations to get this job done. This is a governmental issue.

But Egyptian oil has peaked, and its trade deficit is growing. Nobody is going to pay for the trade deficit to feed 120 million Egyptians. We're not going to volunteer. With the growth rate way down, we are getting to be very, very cheap about foreign aid. Any country that starts to run a food deficit, from now on, is on its own. And this will happen to Egypt next year, basically; the game is up. Every year, they'll be struggling for the resources, financial or otherwise, to feed their people, and pretty soon there will be waves of reasonably well-educated Egyptians attempting to find jobs in Europe. This goes for many other countries on the African continent, and one or two other countries, and the social pressures will be massive.

This is the thought I would like to leave you with. What is going to happen? How are we going to cope? Britain feeds 60 per cent of its people. It needs to import 40 per cent of its food. In order to do that you have to produce something valuable enough to get other people to part with their food. What is valuable enough in the crunch?

The work *Blossom* by Clare Twomey is playing with the elements of nature and our sense of what is precious. The delicate and beautiful blossoms are handmade out of clay and left in their unfired, raw state. Planting them into the soil at the Eden Project they were subjected to the elements, gusts of rain, wind and the cold, leading to their slow disintegration and return to the earth. Beautiful and beguiling as the blossoms were, they vanished, leaving just the traces of their short, startling existence.

THE FUTURE IN PRACTICE

THE STATE OF SUSTAINABILITY LEADERSHIP

Can today's corporations deliver tomorrow's economy?

Pavan Sukhdev

The Great White Sale by David Buckland and Amy Balkin reflects on how the Arctic is 'up for sale' to the highest bidder, a land and sea grab for oil, mineral and fishery exploitation.

Continued...

Can today's corporations deliver tomorrow's economy?

Pavan Sukhdev

Pavan Sukhdev is Founder-CEO of GIST Advisory, which helps governments and corporations understand and manage their impacts on natural and human capital. A career banker, he has spoken at World Economic Forum meetings at Davos in 2010 and 2011, led UNEP projects The Economics of Ecosystems and Biodiversity and the Green Economy Initiative, and is a Visiting Fellow at Yale. His new book, *Corporation 2020* is available from Island Press, www.islandpress.org.

As nations entered Rio+20 to negotiate around the theme of a "green economy in the context of sustainable development and poverty eradication", I was left confused. UNEP's report *Towards a Green Economy* defined a "green economy" as one which increases well-being and social equity whilst reducing environmental risks and ecological scarcities.[1] In other words, a green economy *must* reduce poverty and inequity. So why did the UN feel the need to reiterate this as a tautology in the central theme in the run-up to Rio? By definition, an economy cannot be a 'green economy' *unless* it reduces poverty and achieves the goals of sustainable development.

Perhaps this overemphasis reflects some internal doubt over how far governments really can negotiate a new economic paradigm, given that we live in a world where two-thirds of the economy is private sector, and free markets predominate? Planetary boundaries, like the laws of physics on which they are based, do not seem negotiable either. And they are being approached (and arguably breached) across several critical axes – including greenhouse gas emissions, changes in the nitrogen cycle, freshwater use, land use, food security, the depletion of ocean fisheries, and the decline of coral reefs.

Significant changes are urgently needed within the next decade in the way we deal with the Earth's resources. But the continuing failure of inter-governmental efforts to contain greenhouse gas emissions and to halt or even to slow down the rate of biodiversity loss points to the need to recognise the vital role of the private sector in determining economic direction and resource use globally. The corporate world needs to be brought to the table – but as responsible planetary stewards, and not value-neutral agents free-riding their way to global resource depletion. Here are the reasons why.

There is a growing sentiment in many sectors of society that the 'rules of the game' need to be changed, so that corporations are enabled to compete on the basis of innovation, resource conservation, and satisfaction of multiple stakeholder demands.

The private sector produces almost everything we consume, generating 60 per cent of global GDP. An equally high fraction of jobs globally are provided by corporations. Their advertising drives significant consumption demand. Their production feeds this demand and drives economic growth. Their growing profits and assets are the main magnets for global investment.

These are the good sides of today's corporations – but there are also the bad. Corporate externalities – the unaccounted costs to society of doing 'business as usual' – of just the top 3,000 listed companies amount to an estimated US$2.15 trillion, or 3.5 per cent of GDP, every year.[2] Corporate lobbying frequently influences national policies and politics to the detriment of the public good. Advertising often converts human insecurities into product wants, wants into needs, and needs into excessive consumer demand which has already made humanity's ecological footprint exceed the planet's bio-capacity by over 50 per cent.[3] We are now living by consuming the earth's capital, not its interest.

And yet the free market model remains the rallying cry of many in the private sector. But what they mean by 'free market' is actually the 'status-quo market'. Around $1 trillion a year in perverse subsidies (for fossil fuels, unsustainable agriculture, unsustainable fisheries, etc), and barriers to entry for newcomers and alternative products maintain 'business as usual' while obscuring the associated environmental and societal costs.

There is a growing sentiment in many sectors of society that the 'rules of the game' need to be changed, so that corporations are enabled to truly compete on the basis of innovation, resource conservation, and satisfaction of multiple stakeholder demands – rather than on the basis of who can best influence government regulation, avoid taxes, and obtain subsidies for harmful activities. These rules of the game include policies regarding accounting practices, taxation, financing and advertising practices, which can result in a new corporate model which I call **Corporation 2020.**[4] This new genre of corporation can forge a green economy – one that increases human wellbeing and social equity, decreases environmental risks and ecological losses, and still generates profit.

Corporation 2020 defines the direction today's corporation needs to take to secure itself and become a force for positive change in the economy, society, and the natural environment. It must evolve to create not just financial capital for shareholders, but also human, social and natural capital for all – thus promoting and sustaining the wellbeing of human populations and ecosystems. **Corporation 2020** describes four essential planks of global change: disclosing externalities, resource taxation, accountable advertising, and limited leverage.[5] Each plank seeks a significant outcome in terms of institutional reform, and delivering

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For the new corporation, externalising costs will be bad for reputation, bad for business, and hence a bad idea for CEOs and investors alike.

each outcome is the joint responsibility of different governance institutions together with corporate leaders and first-movers.

Disclosing externalities

Accountancy bodies (IASB, FASB, ICAEW, etc) will have to research and evolve methodologies for measuring the most material corporate externalities (negative externalities in the realm of GHG emissions, water use, land use, pollutants, etc, and positive externalities in the areas of employee education and training, etc) and then formulate guidance and standards for disclosing them in the annual financial reports of corporations. This will provide the missing information needed by corporate managers, governments, civil society, consumers and investors to differentiate their responses to different corporations. The UK Institute of Chartered Accountants (ICAEW) has already launched a global coalition, the TEEB for Business Coalition, with the support of the Gordon and Betty Moore Foundation, and the UK and Singapore governments, with the aim of evolving such methodologies and standards worldwide.

Accountable advertising

Advertising associations, encouraged by consumer protection agencies and NGOs, will have to create more 'information' value in their advertising as against 'selling' value. Social media is already changing who determines advertising today (it is more consumer-driven, less producer-driven) but this trend must be accelerated by institutional support and industry leadership, actively encouraged by industry associations. Penalties and incentives need to be considered to promote 'selling good, not just good selling'.

Limited leverage

G20 Governments and Central Banks will have to monitor and limit the leverage of major corporations. This is not just for banks (which they already do through capital controls), but also any other 'too-big-to-fail' companies with recourse to public funds in times of crisis – insurers, mortgage originators, carmakers, airlines, etc – to ensure that systemic risk from excessive or misused or mis-applied leverage is contained, as this has been the main driver of the last four major global recessions.

Resource taxation

G20 governments (specifically, their tax authorities) must implement changes in the lifecycle incidence of taxation: much more at the point of resource extraction (ie mining of fossil fuels and minerals) rather than at the point of sale (VAT) or of capital formation (Corporation Tax on profits). This will encourage material efficiencies, as against more mining and more volume.

There are other planks of change, such as controls to make lobbying transparent, and introducing new legal forms of corporation such as 'B-Corps'. I consider these useful and supportive, but not critical to the key outcomes that we seek.

The challenge is that these four planks of change are needed urgently, and simultaneously. Planetary boundaries are being breached in terms of climate change, the nitrogen cycle, ocean acidification and coral reef losses, which will in all likelihood impoverish and destabilise societies which are already poor and stressed. This could lead to large-scale migrations and losses of livelihood and life. Global political and economic disruptions are a natural consequence. Unless we can achieve a change in direction globally in a decade we may be acting too late. Therefore civil society, corporate leaders, advertising associations, governments, accountancy regulators and central bankers will need to combine forces and work in an unprecedented and collaborative way, and I believe the result will be a new kind of corporate DNA which gradually dominates and delivers transitions to a 'green economy'.

For this new corporation, externalising costs will be bad for reputation, bad for business, and hence a bad idea for CEOs and investors alike. Creating human and social capital in the societies in which they do business will become not a short-term cost and a CSR strategy, but a wise long-term investment in securing social licence to operate, especially valuable when operating conditions are changing fast, customer loyalty matters, and government intervention is not uncommon.

It is said that a pessimist is one who sees problems in every opportunity, and that an optimist is one who sees opportunities in every problem. By that reckoning, I am an optimist, as I do see in today's complex global problems an opportunity: creating an economy of permanence through an agent capable of delivering it, **Corporation 2020.**

[1] United Nations Environment Programme, 2011. *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*

[2] Report prepared by Trucost, 2010. *Universal Ownership: Why Environmental Externalities Matter to Institutional Investors*

[3] WWF, 2012. *Living Planet Report*. http://awsassets.panda.org/downloads/1_lpr_2012_online_full_size_single_pages_final_120516.pdf

[4] See *Corporation 2020: Transforming Business for Tomorrow's World*, available October 2012 from Island Press. For more information about the book and the Corporation 2020 campaign, visit www.corp2020.com.

[5] These four planks appear as Chapters 4 to 8 in *Corporation 2020:* disclosing externalities, accountable advertising, limited leverage, and resource taxation.

The series *Ice Texts* was created in 2005 and during subsequent Cape Farewell expeditions. "Two hundred years of human excess has resulted in increased CO_2 emissions causing the ice to melt. For the glacier it is barely a single breath, for our children the polar sea ice could be gone forever" (David Buckland).

Leadership: Creating the space to act

Sandrine Dixson-Declève

The fragile figure in *Endangered Species* by Siobhan Davies (2006) gradually becomes overladen, until any movement is brought to a stop.

Leadership: Creating the space to act

Sandrine Dixson-Declève

Sandrine Dixson-Declève is the Director of the Cambridge Programme for Sustainability Leadership's Brussels office and The Prince of Wales's EU Corporate Leaders Group on Climate Change.[1] She is an international expert with over 20 years' experience in environmental, sustainability, energy and fuel policy development and regulatory analysis. She has run and worked for consulting companies and has been the personal adviser to several Members of the European Parliament, the European Commission, and national governments, as well as international organisations including OPEC, the OECD, UNEP, and USAID. She is the Vice-Chair of the European Biofuels Technology Platform, and is a member of The Guardian's Sustainable Business Advisory Board.

Europe's policy leaders at all levels of the political ladder – from the EU institutions to the member states – are confronted daily with short-term economic challenges. As a result, sustainability and climate issues are often set aside, and leadership is waning.

The hallways of the EU's headquarters in Brussels and national capitals are full of frantic advisers, trying to provide the right expertise for policy leaders who are struggling to keep Europe afloat. Yet among all the Eurozone chatter is the persistent, nagging climate and sustainability buzz created by brave leaders in the public sphere, business and civil society, who keep on unveiling the risks of ignoring climate change and resource depletion. In the minds of these farsighted leaders, the risks of not acting today are just as important as the short-term Eurozone and economic crisis, and, if left unanswered, could be even more catastrophic than regional economic collapse.

Their message is simple: the European response to the crisis cannot be limited to fiscal austerity, structural reform, and saving dinosaur industries. Instead, Europe must come up with an industrial innovation and transition plan, which boosts economic growth and job creation through reform of the economy in parallel with short-, medium- and long-term resource efficiency and low-carbon investments – all of which will stimulate economic development and job creation. We need a logical leadership plan, in a context of economic and political parity, where EU member states are all of the same opinion and understand the true value of a strong and competitive Union. Unfortunately, Europe is struggling to pull the Eurozone and Union together, not only economically, but also politically.

[1] The EU Corporate Leaders Group on Climate Change (EU CLG) was set up in 2007, bringing together business leaders from a cross-section of EU and international businesses who believe there is an urgent need to develop new and longer-term policies for tackling climate change. The Group was brought together by The Prince of Wales and is managed by the Cambridge Programme for Sustainability Leadership.

The response to the Eurozone crisis cannot be limited to fiscal austerity, structural reform, and saving dinosaur industries.

The regional challenge

One cannot underestimate the important differences between Eastern and Western European approaches to governance, political negotiation and economic growth – nor the impact these dissimilarities have on moving forward towards a united and innovative vision. One can also not forget the years of inherent distrust built up in the newly-independent Central and Eastern European countries towards those seen as pushing their perspective over all others – whether the former Soviet Union, or Western European democracies promoting new low-carbon economic development and innovation policies.

Central and Eastern European nations, in particular Poland, are quick to remind Western European governments that the bulk of environmental and climate legislation was developed before their entry into the Union, and that although the body of EU legislation has to be implemented in their countries, they do not always feel inclined to agree with it. In fact, as I was recently reminded by several Central and Eastern European ambassadors to the EU, policy leaders and citizens in these countries are still sceptical about climate change, and reducing consumption or becoming more efficient is contrary to their new leadership stance on promoting economic growth – a growth which is symbolic of the new 'Western' values they embraced when abandoning Communism and centralised economies.

One cannot forget the years of inherent distrust built up in the newly-independent Central and Eastern European countries towards those seen as pushing their perspective over all others.

This, of course, is similar to arguments used by developing countries across the world: just because the West used resources inefficiently to fuel its economic development, this does not mean that 'developing' or 'transition' economies should not grow in the same way now that they are faced with resource depletion and climate change. Of course, the response seems simple: economic development should occur, but differently, and the 'mistakes' made by Western governments should not be replicated. The challenge is quite what an appropriate distribution of resources and growth would look like, and how to persuade Europe's newest Central and Eastern European leaders to accept and sell this solution to their citizens. But to be fair, this is not only an issue in the Central and Eastern European region. One just needs to look at the recent French and Greek elections to realise that all candidates focused their campaigns on economic stability and a rejection of economic austerity, without any consideration for climate change issues or even green growth opportunities.

So, how do we re-build Europe's confidence to lead on sustainability and climate change, when half of the region's countries are convinced of neither the direct benefit to them, nor the relevance of these issues to their economic growth?

Collaboration towards green growth

On 3 May 2012, some of Europe's largest companies met with President Barroso, Climate Commissioner Hedegaard, Commissioner for the Environment Potočnik, Director Generals from three Directorates, and Commission staff,

Putting the necessary flesh on this 'green growth' story, and leading member states and Europe's global partners to the table, is today's key challenge; Europe cannot lead if the member states and countries across the globe do not follow.

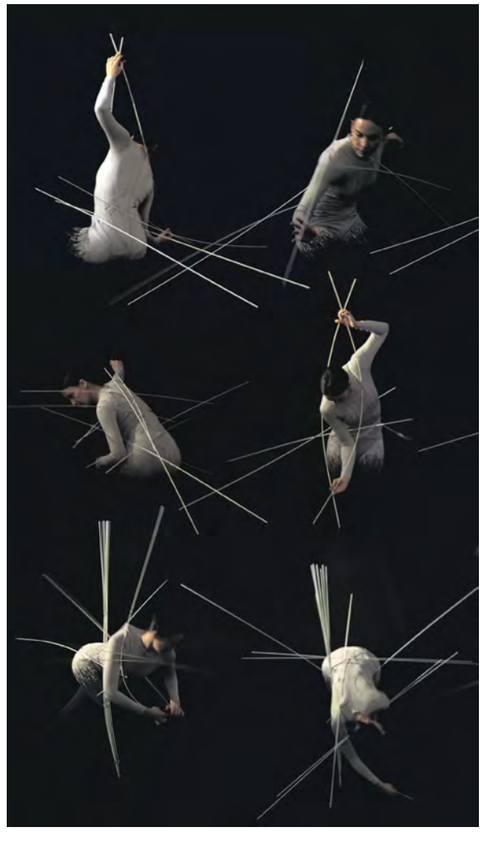
to address this leadership vacuum. They discussed the prospects for EU leadership on development and climate issues, in preparation for the UN sustainable development conference in Rio+20, and the UNFCCC's Conference of the Parties in Qatar in December 2012.
The meeting was organised by The Prince of Wales's EU Corporate Leaders Group on Climate Change (EU CLG) and the Brussels office of the University of Cambridge Programme for Sustainability Leadership.

At the meeting and in private conversations, President Barroso's message was loud and clear. He questions how we can move from an era of austerity to an age of prosperity if people do not believe in the benefits of green growth, and is adamant that creating a viable and believable green growth story is the only way forward. The President not only sees the business community and corporate leaders as natural allies in the European Commission's work towards green and sustainable growth, but also, most importantly, he is convinced that pushing a low-carbon economy is a key growth strategy. Odd as it may sound, he believes, the crisis is an opportunity to make progress towards growth and a new, greener industrial way. But he, along with other key players, agrees that this won't be easy.

Putting the necessary flesh on this 'green growth' story, and leading member states and Europe's global partners to the table, is today's key challenge; Europe cannot lead if the member states and countries across the globe do not follow. There are several possible avenues for Europe to truly move forward in its green growth strategy. These depend on building trust and a better understanding of the psyche of the Central and Eastern European region, addressing the growing wave of Western European economic panic, and finding more non-European buy-in to the green growth story.

The Clean Energy Finance Solutions project undertaken by CPSL's Brussels office is a small step down the path of trust-building. By working with local renewable energy experts and the finance community, we have opened up a dialogue in Bulgaria, the Czech Republic, Hungary, Poland, and Romania around the necessary elements for a stable transition towards a low-carbon economy. Based on a sound assessment of the barriers and opportunities for finance in renewable power generation, we were able to open discussions around the finance mechanisms needed to enable a genuine switch from 'black' to 'green' energy.

Not only has the project successfully convened government officials and major stakeholders around a common goal of growth and job creation, but it has now won buy-in from all



Our demand for food, feed and fibre is projected to increase by 70 per cent by 2050. Yet already today, 60 per cent of the ecosystems underpinning these resources are degraded. Without efficiency gains, by 2030, we will need 40 per cent more water than we can access.

stakeholders around a second phase of capacity building. The entire project may now be replicated across the Central and Eastern European countries of the entire Danube Region.

Non-European green growth and low-carbon buy-in is essential, not only to decarbonise and preserve our natural capital globally, but also to convince member states hiding behind economic arguments against decarbonisation that non-EU countries will have a competitive lead, if we do not invest in low-carbon technology and services.

With this in mind, as President Barroso was on his way from our meeting to meet the Vice-Premier of China, Li Keqiang, I called upon him to continue to build an EU-Chinese dialogue embracing market access for low-carbon technologies in China, and addressing issues around embedded carbon and the fair pricing of all externalities. We all know that the population of China today is 100 times greater than that of the United Kingdom during the Industrial Revolution, and China will achieve levels of growth in 10 years that took the UK 100 years to attain. So we are talking about a potential resource shock that will be 1,000 times greater, in China alone.

In order to meet the predicted growth of the world's population to 9 billion, we will need three times as many resources – 140 billion tonnes annually – by 2050. The demand for food, feed and fibre is projected to increase by 70 per cent. Yet already today, 60 per cent of the ecosystems underpinning these resources are degraded. Without efficiency gains, by 2030, we will need 40 per cent more water than we can access.

The issue of fair pricing and allocating a value to externalities is firmly anchored in the European Union's 2020 Growth Strategy, which promotes sustainable development as a core factor for economic growth. Last year, under the leadership of the visionary new Slovenian Commissioner for the Environment, Janez Potočnik, the European Commission declared that resource efficiency and proper costing of natural resources will actually boost the economy, improve economic performance and stimulate innovation. At our meeting on 3 May, Commissioner Potočnik called upon companies to join him in building the case for an inclusive green economy, which fosters growth and poverty eradication, offering opportunities for all countries around the world in all stages of development. He stressed that leadership must focus on clear goals around five 'pillars of life': energy, water, land, ecosystems, and waste.

Beyond growth?

To put in place the right policy frameworks enabling greener growth and resource use, Commissioner Potočnik has invited business and civil society leaders to join a new High-Level Resource Efficiency Platform.
Unfortunately society has not yet moved away from the need for quantification, and therefore any green growth narrative will need to be substantiated by the clear measurement of impacts, scientific results, and economic analysis.

Yet Jacqueline McGlade, Executive Director of the European Environment Agency (EEA), which is in charge of quantifying and qualifying Europe's environmental trends and impacts, stresses that only focusing on economic measurement is not the right approach. McGlade is becoming a leader in her own right through her efforts to broaden the debate

China will achieve levels of growth in 10 years that took the UK 100 years to attain. We are talking about a potential resource shock that will be 1,000 times greater in China alone.

"The economic crisis, accelerating environmental degradation and growing discontent around the world all point to one conclusion: GDP as the sole measure of success has reached the end of the road." Lyonchoen Jigmi Yoezer Thinley, Prime Minister of Bhutan

around quantification and pure economic assessment.

"The world needs to move away from measuring success in purely economic terms, and should instead consider other criteria, including the distribution of resources, sustainability, health, human rights and education," according to McGlade. Most environmental analyses carried out by the EEA now address decoupling environmental damage and economic growth, to achieve continued prosperity without destroying the natural systems that sustain us. The EEA is also working on alternative approaches to measuring progress, such as valuing the services provided by ecosystems which are essential to human wellbeing.

This work appeared at a landmark, high-level UN meeting in April 2012, calling for new measurements of wellbeing in the run-up to Rio+20. 'Happiness and Wellbeing: Defining a New Economic Paradigm' was hosted by the Government of Bhutan, renowned as 'the happiest nation in the world', at the UN headquarters in New York. It brought together hundreds of representatives from governments, religious organisations, academia and civil society, and was chaired by McGlade. Speaking at the meeting, UN Secretary-General Ban Ki-Moon said: "We need an outcome from Rio+20 that says that happiness and wellbeing are measured in more than gross national income – and that they are fundamental goals in themselves."

The Prime Minister of Bhutan, Lyonchoen Jigmi Yoezer Thinley, agreed. "The economic crisis, accelerating environmental degradation and growing discontent around the world all point to one conclusion: GDP as the sole measure of success has reached the end of the road," he commented. "In the future, we will look back on this meeting as a turning-point… Many of the most influential people in the world agree that we need to reconsider what makes us happy. It is clearly not rampant consumerism."

The discussion around happiness and wellbeing indicators has recently spread to a series of unexpected places: France and the UK, with reports being published in both countries. Although the Prime Ministers of these countries have not come out clearly on whether such indicators should complement or replace GDP, this openness to new thinking around growth is heartening, and is being complemented by new leadership on resource efficiency and consumption from other quite unpredictable sources such as the International Energy Agency.

Walking Dance, Siobhan Davies (2005)

What next?

Even though Europe's more progressive policy and business leaders were represented at Rio+20, and not only voiced their commitment to sustainable development, but also demonstrated real implementation on the ground, the final text was a disappointment.

Why did progressive business allow this to happen? Greenpeace International Executive Director Kumi Naidoo goes as far as accusing business interests and 'business as usual' as the main reason for failure in leadership. "We didn't get The Future We Want in Rio, because we do not have the leaders we need. The leaders of the most powerful countries supported 'business as usual', shamefully putting private profit before people and the planet."

Yet 'business as un-usual' was present at the conference. Most members of the business community attending demonstrated their commitment to sustainable growth and consumption at a series of side events, and through a variety of agreements including the CPSL-led Natural Capital Leadership Compact. This urged international governments to commit to a global policy framework on the responsible and sustainable use of natural resources. Some would claim that the BRICS countries, led by the Brazilians as chief negotiators, simply refused to listen to the progressive proof and viability of green growth.

The burden falls on progressive businesses to create the political space for policymakers to make tough decisions… The business community is one of the strongest factors influencing political decision-making, and so must visibly be part of this call for change.

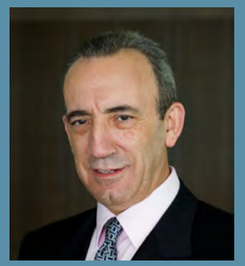
Post-Rio+20, the burden therefore falls on progressive businesses to create the political space for policymakers to make tough decisions, in order to deliver a new, robust, resource-efficient and climate-resilient economic vision – EU-wide and worldwide. The business community is one of the strongest factors influencing political decision-making, and so must visibly be part of this call for change. Once business has made the first steps by demonstrating its belief in green growth, and governments are willing to listen and take this cue to regulate for sustainable development, this will catalyse change.

In Europe that means the story must be sold by business to governments in Central and Eastern Europe. Globally, the same must happen in the US and BRICS countries. Business must shoulder this burden jointly with governments, and show true leadership.

To the dancer Siobhan Davies, the idea of protection, of care, seemed particularly momentous in the ferocious and cold environment of the Arctic. "I sense a cold, I sense a vulnerability. I feel myself as something hot and bloody. My body, if it were harmed, the flesh would bleed. So if I find the little bit of warmth I have, I need to protect it." Movement was her answer with *Walking Dance* (2005).

Building the Future

UNIVERSITY OF CAMBRIDGE
PROGRAMME FOR SUSTAINABILITY LEADERSHIP
25 YEARS



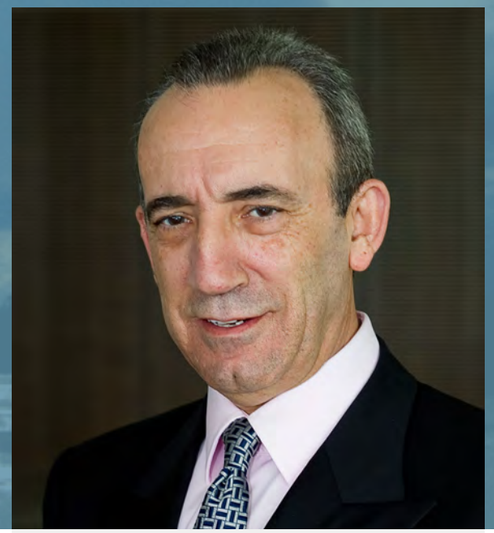
Keeping nature's balance sheet in balance

José Lopez

The River was shot in 2010 by Brenndan McGuire, as he journeyed down the Amazon with a team of artists and scientists.

Keeping nature's balance sheet in balance

José Lopez



José Lopez, an engineer and Spanish national born in 1952, is Nestlé S.A.'s Executive Vice President of Operations and GLOBE. In a career spanning more than 30 years at Nestlé he has held a number of positions including Operations Director of the Oceania region and CEO of Nestlé Japan, before taking up his current role on Nestlé's Executive Board where he is responsible for Procurement, Manufacturing, Supply Chain, Engineering, Quality Management, Agriculture, Safety, Health & Environment and Operations Performance. He has acted as President of the Malaysian International Chamber of Commerce and Industry and as Ambassador for Kobe during his tenure in Japan, and, since 2010, has sat on the Advisory Board of the University of Cambridge Programme for Sustainability Leadership.

Sustainable development – providing sufficient material and spiritual well-being to enable a good life for all of humankind, within the limits imposed by our one planet – is by definition a concept with global reach. This has significant implications for policymakers and the private sector alike, which influence each other.

Yet global negotiations on climate change, and many regional challenges around increasingly limited water resources, are characterised by a dilemma: almost everyone acknowledges that the world would be better off through co-operation, but as countries and regions don't trust each other enough, each player tends to favour their own, short-sighted advantage. Governments and businesses approach the challenge as though it were just another round of the famous ethical conundrum 'The Prisoner's Dilemma', creating the result that everyone may get caught out by environmental collapse – just like the two prisoners who betray each other in the false hope of a more lenient verdict.

To escape from the prisoner's dilemma in the area of climate change an international policy mechanism has been put in place, the UN Framework Convention on Climate Change – however imperfect this may be. But climate change is only one aspect of the much broader concept of 'natural capital': the sum of all mineral, hydrological, fossil and biological resources, and the ecosystem services they provide as an essential input for human activities – clean drinking water, food, timber, climate regulation, recreation, and many more.

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Let's look at this idea of natural capital through the lens of a business leader. Assessing the health of our own companies, we typically use three main financial tools: cash flows, income statements and the balance sheet. Looking at any of these in isolation doesn't tell you the full story.

Now imagine you're appointed CEO of Earth Ltd. You would have some kind of cash flow and income statement at your disposal: global GDP, which currently stands at some US$65 trillion. An impressive success story! But what about the balance sheet? There is simply no equivalent accounting mechanism in place that could give you a sense of the natural capital available to run your company. In fact, a standing forest is worth literally nothing in national accounting terms, while a forest that is cut down contributes to GDP. The lost forest is not accounted for as a liability on the Earth's balance sheet, in the same way as the standing forest was not counted as an asset. Both are externalities that are not reflected in today's prices. But someone will have to pay the bill, probably sooner rather than later.

Estimates of the economic value society derives from the living environment are of an order of magnitude similar to global GDP itself. But until recently, these services were simply taken for granted. Only now, as we draw down nature's capital, we realise that the diminishing asset base begins to yield diminishing returns.

As the world's largest food company, Nestlé turns nearly one per cent of the world's agricultural output into food and beverages. Responding to the nutritional needs of our consumers, we depend probably more than most other businesses on functioning ecosystems and a sound environment. And as a whole, the agro-food sector faces the considerable challenge of producing food that is not only safe, nutritious, and affordable for all, but that is also produced in a way that keeps nature's balance sheet in balance.

Yet, as long as the real costs of natural capital are not internalised – ie not borne by businesses, and ultimately by consumers – according to a fair, equitable and global level playing field, markets do not receive the right price signals and financial capital continues to flow in directions that do not always help to preserve natural capital. In other words, companies are often caught in the same prisoner's dilemma as countries and politicians: nobody dares to make the first move. The politician does not dare to act because he fears the verdict of the voter, and the business leader because he fears the verdict of the customer or shareholder, as a full internalisation of costs would lead to potentially significant price increases.

Like many other leading companies, at Nestlé we are trying to build the necessary trust to overcome the dilemma in three main ways.

Leading by example in our own operations and areas of influence

For many decades we have focused our activities on making our own manufacturing sites more eco-efficient. Since 2001 we have reduced water withdrawal by 28 per cent

Climate change is only one aspect of the much broader concept of 'natural capital': the sum of all mineral, hydrological, fossil and biological resources, and the ecosystem services they provide as an essential input for human activities.

and greenhouse gases by 17 per cent, while increasing production volume by 73 per cent. We apply high environmental standards wherever we operate, including in areas where regulatory expectations were much lower than our own.

Here, too, we have faced a dilemma, for example when building wastewater treatment plants in countries where none was required by law. Our local management would, quite rightly, argue that similar investments were not being made by local competitors, and so for us to pursue them increased our production costs and might eventually price our products out of the market. This is a typical example of what we mean when we say we don't compromise our long-term development for short-term gains. What may indeed have been a certain cost disadvantage in the short term turned out to make our business more sustainable in the longer term: often we set expectations that led to stricter regulations over time, requiring local competitors to upgrade their operations too.

Beyond our own 461 factories in 83 countries, we have many other opportunities to improve the management of natural capital through our complex value chains. Most importantly, this involves helping farmers through our network of 1,000 agronomists to make agricultural production more efficient, while preserving the natural capital that delivers the ecosystem services we all rely on. Nestlé was the first company to commit to eliminating deforestation from its supply chain. We extended our traceability program beyond palm oil, and pulp and paper, to 10 further areas and main commodities. We have also partnered with The Forest Trust and other groups to map our supply chains and to assess

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our suppliers' compliance with our responsible sourcing guidelines, while providing technical support to those committed to achieving sustainability.

We are convinced that the only way to feed an increasingly urbanised global population is by leveraging modern technologies responsibly and by reducing waste and inefficiencies all along the value chain. The economies of scale provided by today's agricultural and food system has made more food more affordable for more people than was thought possible only a few decades ago.

Public policy and action-oriented dialogue to address the natural capital 'overdraft'

However, business action alone will not be sufficient as long as most policy frameworks favour the short term over the longer term and provide the wrong incentives. We therefore engage in policy dialogue at local, regional and global level with two clear messages. We are against misguided subsidies, in particular those that are detrimental to natural capital, as is the case with subsidising the conversion of food to fuel. The massive use of food for fuels has become a major driver for food price increases, with the worst consequences for those least able to afford higher prices. Furthermore, most scientists now agree that agrofuels are worse for the environment than fossil fuels, if all externalities such as water withdrawal, pollution and the knock-on effects of land-use changes are taken into account.

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We also advocate that everyone should pay at least for the cost of the water used in the products they consume. Water is subsidised by the taxpayer in many parts of the world (usually, in fact, through public debts inherited by tomorrow's taxpayer), with the consequence that there is little incentive to conserve this most precious of natural resources. Obviously, any reform of the water market has to be done in a socially just and responsible way, guaranteeing the human right to water and providing for the vital needs of those who are unable to pay for it.

While being against misguided subsidies, we are equally strongly for an international policy framework to leverage market forces to internalise those costs that are currently not even accounted for, and that draw down

Nestlé was the first company to commit to eliminating deforestation from its supply chain.

The challenge here is to engage with consumers in a way that is honest, fact-based, and looks at the sustainability performance of the entire lifecycle of a product rather than exaggerating individual aspects, which will sooner or later be exposed as 'greenwashing'.

natural capital. We realise that this is a probably one of the most complex challenges facing mankind in the 21st century and we don't believe there will be a quick fix. This is why we support the Cambridge Programme for Sustainability Leadership and its Natural Capital Leaders Platform, which brings together leading thinkers and practitioners in the search for pragmatic and practical solutions.[1]

Another example of a successful policy dialogue is the 2030 Water Resources Group initiated at the World Economic Forum, which involves the International Finance Corporation of the World Bank Group, McKinsey & Company, and a consortium of business partners. Under the leadership of Nestlé Chairman Peter Brabeck-Letmathe, the Water Resources Group seeks new insights into water scarcity, explores the opportunities and costs of possible solutions, and fosters results-based stakeholder dialogue. It has established and successfully tested a new methodology, the water cost curve, which guides policymakers in making the best possible choices to balance demand and supply in any given watershed. What started essentially as a private sector initiative is now being adopted by a growing number of regional bodies, with a multi-stakeholder approach as one of its key features.

Leveraging growing consumer awareness for competitive differentiation

While responsible supply chain management and policy dialogue require a high degree of often complex collaborations with countless stakeholders, the third element that nudges actors towards more sustainable choices is based more on competition than on collaboration. Competition for better solutions has been the major driving force behind economic and indeed social development. I believe it is a sign of maturity that sustainable development over the past few years has entered the competitive landscape, and that sustainability has become a driver for competitive differentiation.

While many more consumers claim they are willing to pay more for more sustainable products than practise what they preach, I am convinced that sustainability becomes an increasingly important 'tie-breaker' in consumers' decisions. There are indications that consumers do increasingly give preference to products they perceive as more sustainable, offering them 'peace of mind' as part of the product proposition as long as there are no trade-offs in other aspects of performance.

The challenge here is to engage with consumers in a way that is honest, fact-based, and looks at the sustainability performance of the entire lifecycle of a product rather than exaggerating individual aspects, which will sooner or later be exposed as 'greenwashing'. What is required is fair competition, based on a level playing field established through collaboration between all stakeholders. We actively support several initiatives around the world that establish scientifically reliable and uniform environmental assessment methodologies and communication tools, such as the European Food Sustainable Consumption and Production Round Table.

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Conclusions

Sharing the benefits of our planet's limited natural capital equitably among today's societies, and preserving them for future generations, requires both collaboration and fair competition, based on mutual trust and understanding between all three major constituencies: businesses, policymakers and citizen-consumers. To overcome the prisoner's dilemma we need to put a value on natural capital and identify the most appropriate levers to drive progress. These levers will probably include pricing, but also incentives, taxes, and other forms of regulation, as well as voluntary approaches.

The challenges of keeping nature's balance sheet in balance represent an overwhelming agenda for any company. At Nestlé we have decided to focus our contribution in particular on two areas that are core to our business strategy and vital to the welfare of society: water, the most precious of natural resources, and rural development. Together with nutrition, these form the pillars of what we call Creating Shared Value, the basic way we do business, founded on the belief that in order to create long-term value for shareholders, we have to create value for society.

[1] The Natural Capital Leaders Platform is a major business-led programme focusing on practical action and policy influence. Influential companies with a global reach are working to address the impacts of ecosystem and natural capital loss and degradation on business, their customers and wider society by: triggering significant changes in the business response to sustaining ecosystems and natural capital globally; demonstrating business support for progressive government policy and action; and stimulating new ways of thinking, so that the future direction taken by business and government addresses risks and grasps opportunities in relation to natural capital.

In 2010, Cape Farewell embarked on its ninth art and science voyage, not to the Arctic but to another hotspot of climate change: the Peruvian Amazon. Brenndan McGuire captured through video and sound recordings his path into this hostile and yet vibrant, rich, and sensitive environment. His footage inevitably mirrors his own "feelings and the sense of nostalgia when journeying down the river" (Brenndan McGuire).

Business as part of the solution

Carlos Fadigas

Leafcutter Ants: artist Daro Montag explores how an unexpected oily line compels ants to adapt, incorporating the knowledge of a new carbon threat into their worldview.

Business as part of the solution

Carlos Fadigas

Carlos Fadigas is the CEO of Braskem, a key player in the global market for thermoplastic resins. After completing a Business Administration degree at the Universidade de Salvador and an MBA in Switzerland, he began his career in Citibank, going on to work for the Odebrecht Group, OPP Petroquímica, and CNO. In 2007 he joined Braskem as Chief Financial Officer and Investor Relations, and became overall CEO in December 2010. Braskem is a member of EPC (Empresas pelo Clima), a Brazilian business group belonging to the international Corporate Leaders Network for Climate Action.

There are many roles for business in developing sustainability, but the most important is to integrate sustainability principles into business strategy. Sustainability means much more than just worrying about the environmental impacts of business operations – this only represents 'business as usual'. I prefer the idea of looking for the business opportunities that could arise from the huge challenge of trying to raise living standards for a likely population of 9 billion in 2050, yet remaining within the limits of our planet.

That challenge is tied to the 2°C limit for the rise in average global temperature negotiated at the UNFCCC conference. Seeking business opportunities within these constraints is much more attractive and strategic.

On the other hand, efforts to address the impacts of business operations should not be underestimated. This should be viewed as the basis for all sustainability strategies. Companies should start here; this is what we did at Braskem, and we are proud of the results we have achieved. Since 2002, when Braskem was established, our accident rates have fallen by more than 80 per cent and are now at levels similar to those of the best-performing companies around the world. The intensity of our solid and liquid waste outputs has fallen by more than 60 per cent; effluents (waste water) by more than 35 per cent. Greenhouse gas emissions have fallen more by than 11 per cent between 2008, the year that we arrived at a consistent methodology for testing, and 2011. These figures provide only a few examples.

Sustainability means much more than just worrying about the environmental impacts of business operations – this only represents 'business as usual'. I prefer the idea of looking for the business opportunities that could arise from the challenge.

But this is not enough to meet the sustainability challenge. Since the Rio United Nations conference in 1992, there have been many important achievements. But global and local research reveals the multiple challenges we face in aiming to reach standards of living for everyone that could be considered decent. There are more than 1.6 billion people in the world who lack access to clean water, and 900 million starving or undernourished people.[1] There are also clear signals that the planet's environmental capacity is overburdened. Natural resources, such as minerals or sources of energy, the environmental sinks where we deposit our waste, or our atmosphere, are becoming scarce. Greenhouse gases continue to accumulate, and global temperatures continue to increase. At the local level, the situation is not so different. In Brazil, Braskem's home country, in 2009 we had more than 60 million people living on less than US$2 per day, and about 10 per cent of our population over the age of 15 was illiterate. In 2008, more than 40 per cent of homes lacked access to a sewerage system.[2] Of course it is necessary to do much more; and this also brings opportunities.

Each business and each industry can analyse itself and ask what concrete contribution towards sustainability it could make, or how its contributions could be more significant. Or, what revolutionary solutions could be developed by its team and deployed to the market? The answers will come, and with a few innovations each organisation could differentiate its business position.

At Braskem, we found a local opportunity that could differentiate us from the rest of the world. The use of renewable raw materials for chemical production has enormous potential in Brazil. There are two aspects of this: the large-scale production of ethanol from sugar cane (Brazil is the second-largest ethanol producer in the world), and the greater efficiency and productivity of this process compared to competitors like corn from USA and beet from Europe. To offer just one example, for each unit of energy used to produce ethanol, 9.3 units of energy are produced when sugar cane is used, 1.4 units when corn is used and 2.0 units when beet is used. Taking this into account, at Braskem we decided to invest in technology development and took the risk of investing in the biggest industrial facility in the world to produce our biopolymer 'green polyethylene'.

At Braskem, we found a local opportunity that could differentiate us from the rest of the world: the use of renewable raw materials for chemical production.

We have invested about R$500 million (more that US$250 million) in this facility.

As well as the fact that green polyethylene is based on a renewable raw material, three other characteristics are drawing the attention of many clients. Firstly, green polyethylene is very easy to use because there is no need to adapt our clients' equipment. Green polyethylene can be recycled using the same processes that are in place for traditional polyethylene. More importantly, it captures and, while solid, sequesters 2.5 tons of CO_2 equivalent per tonne of polyethylene produced over its lifecycle from the cradle to the gate of our facility. Transforming the CO_2 in the atmosphere into plastics is really a very smart way of using it. We are happy that many companies value this solution; Coca-Cola, Procter & Gamble, Danone, Johnson & Johnson, Nestlé, Tetra Pak, Estrela, Natura, Faber-Castell, Chanel, Toyota Tsusho and others are already our clients. This is why we have decided to increase our

Co-operation is another very important aspect of our strategy, in order to mitigate risk. When we were developing green polyethylene, we counted on the support of one of our clients to help us with the first step of investing in technology development.

spending on innovation and technology. Last year this reached R$155 million (about US$63 million). We have already announced the construction of a new facility to produce another biopolymer: renewable, raw material-based polypropylene. And new products are in our research and development portfolio.

Co-operation is another very important aspect of this strategy, in order to mitigate risk. When we were developing green polyethylene, we counted on the support of one of our clients, Toyota Tsusho, who decided to help us with the first step of investing in technology development. After that, new partnerships were established. Upstream, we knew that there were many concerns about the production of Brazilian sugar cane, so we decided to put clear environmental and social requirements in place for Braskem ethanol suppliers. A code of conduct was developed with the support of a specialist NGO, ProForest. We also received some incentives from the Rio Grande do Sul, a southern state of Brazil, to build our facility there. This demonstrates how important co-operation was in putting this solution into practice.

Another aspect of our strategy, which I also consider an important role for business in general, is to support the development of an improved, sustainable quality of life for everyone. This means that we should work

I believe co-operation and competition can co-exist, creating solutions that attract public attention and bring profits to a company.

There will be no sustainability without the participation of the economic mainstream and of business and industry. This will only have been achieved when all companies position themselves as part of the solution.

with our value chain and with society to put new solutions in place for our modern way of life. The greatest challenge is how to evaluate different possible solutions in order to decide which is most sustainable. This is why we are conducting Lifecycle Analyses and supporting lifecycle thinking among teenagers in schools. Last year we provided 1,577 Brazilian schools with teaching materials to do this.

In conclusion, I would like to address an often-cited aspect of the debate which I consider a false dilemma: the criticism that sustainability limits competition. I know that I described above how co-operation was one of the most important aspects of the success of green polyethylene, and one of the core values of sustainability activities. But, at the same time, competition and the appetite for differentiation are what inspires entrepreneurialism. This means that I believe co-operation and competition can co-exist, creating solutions that attract public attention and bring profits to the company. For businesses, there is no way of surviving without profit; therefore the economic dimension is inherent to business sustainability, which is, in my view, central to global sustainability. This is why one of the two themes of the Rio+20 conference which took place in June 2012 was "the green economy in the context of sustainable development and poverty eradication".

There will be no sustainability without the participation of the economic mainstream and of business and industry. And this will only have been achieved when all companies position themselves as part of the solution, and integrate sustainability principles into the heart of their business strategies.

[1] UNEP, 2011. *Towards a Green Economy*

[2] IBGE, 2010. *Indicadores de Desenvolvimento Sustentável* and *Síntese de Indicadores Sociais da População Brasileira*

Daro Montag is an artist and Reader in Art & Environment at University College Falmouth. His work explores the inherent creativity of living organisms. The video work *Leafcutter Ants* was inspired by Daro's trip with Cape Farewell into the so-called 'Cloud Forests' of the Peruvian Amazon and Andes. It documents with scientific accuracy how 'an organism in motion' will respond when an oily line of carbon disrupts their path: "What happens when they encounter this totally unexpected intrusion into their world?" The work was commissioned for the Cape Farewell exhibition UNFOLD, now touring globally.

Hard limits – flexible strategies

Mike Brown

Sunand Prasad's work *Greenhouse Gas* sets out to delineate 540m^3, and represents one tonne of CO_2, the average monthly CO_2 emission of each person living in the UK.

Hard limits – flexible strategies

Mike Brown

Mike Brown is Chief Executive of Nedbank Group Limited, one of the major South African banks, and a member of the South African Corporate Leaders Group on Climate Change.[1] He was previously Chief Financial Officer and Head of Property Finance at Nedbank, and an executive director of BoE Limited.

COP17 – the 17th Conference of the Parties for the United Nations Framework Convention on Climate Change – proved a catalyst for South African business to engage more deeply with the challenges of climate change. What became clear through my attendance at the event, and my active participation in the South African Corporate Leaders Group on Climate Change, is that the global climate system is not open to negotiation.[1]

Though humans are affecting it profoundly, the global climate system will follow the inexorable laws of physics as it absorbs the carbon and other gases we have been pumping into the atmosphere, and we will be left with the consequences. If the climate system speaks to us, it will be only be through those consequences.

Nedbank, where I have been Chief Executive since 2010, has long prided itself as a regional leader in taking sustainability seriously. That said, it was only when the idea of a global carbon budget was explained to me prior to COP17 that I began to include the notion of 'hard limits' in my understanding of what businesses must do to respond to the problem.

I find the concept of a global budget for carbon emissions, which must not be exceeded if we are to avoid runaway climate change, quite appealing. Budgets are the stock-in-trade of businesses so this is a language I and my colleagues feel at home with. At Nedbank, our annual business planning process is a mixture of top-down targets and constraints, combined with bottom-up aspirations and plans from within the organisation. Taking into account what we now know about the earth's climate system, the critical difference from usual planning is that the top-down constraints implied are not only non-negotiable, but also, if breached, carry penalties for future generations far beyond the scale of even the worst business failure.

[1] The South African Corporate Leaders Group on Climate Change was set up by the South African office of the University of Cambridge Programme for Sustainability Leadership, with the intention of developing and articulating a progressive voice on climate policy and strategy from the business community. The group is affiliated to the global Corporate Leaders Network for Climate Action.

The critical difference from usual planning is that the top-down constraints implied are not only non-negotiable, but also, if breached, carry penalties for future generations far beyond the scale of even the worst business failure.

The mathematics of a global carbon budget can be set out quite simply. According to research by Meinshausen and others, if we are to give ourselves a 75 per cent chance of staying below the 2°C temperature increase that governments have committed to, then we must restrict our 2000–2049 emissions to 1,000 gigatonnes of CO_2. Allowing ourselves a further 440 gigatonnes raises the risk of exceeding 2°C to 50 per cent – a level of risk I would not want to take.

I cannot imagine a clearer, harder limit for the global economy to have to work within. The implications for a national economy such as South Africa's, and a bank such as ours, are at the same time both refreshingly straightforward and breathtakingly harsh. In South Africa, we face the task of working out what our equitable share of that global carbon budget amounts to (a process indicated by the Durban Platform that emerged from COP17), and then determining how, as a national economy committed to reversing poverty and inequality, we use that carbon budget most effectively to ensure the best possible outcomes for society.

The first thing that struck me about this challenge is that it has few, if any, precedents. We are all accustomed to negotiations where, when push comes to shove, there is a degree of flexibility on both sides. This is certainly so in the world of business and finance and, it seems to me, in the world of politics and government. In these familiar worlds there is really no such thing as an immovable object. With the global carbon budget, however, we are in different territory. For all that there must be some degree of imprecision in the exact details of the science, with our present state of knowledge we would surely be negligent to assume that 1,000 gigatones of emissions was a flexible target. The consequences of getting it wrong are so enormous that the only ethical principle to adopt is surely one of precaution.

So what will it mean for us, as business leaders, to negotiate with government and amongst ourselves within such a 'hard limit'? Some or all of our businesses will clearly have to make tough adjustments. I think three things will become crucially important:

Firstly, all parties will need reliable data, and enough of it, upon which to base our discussions. Hard decisions will need

What will it mean for us, as business leaders, to negotiate with government and amongst ourselves within such a 'hard limit'?

While we must treat the 2°C threshold as a hard limit, our strategies for delivering vibrant businesses and a growing economy within this should be as flexible and innovative as we can make them.

to be taken and I believe it is possible for our scientists and economists to provide us with the assessments of risks and costs that we will need.

Secondly, for South Africa to arrive at a plausible, widely-supported national plan for transition from its present high-carbon intensity to a low-carbon, climate-resilient economy within 40 years, doing its fair share, a mature leadership dialogue will be required. We in business must negotiate on the assumption that government and business must work together to ensure appropriate legislation and regulation, as it seems unlikely our goals can be achieved solely through voluntary action.

While we must treat the 2°C threshold as a hard limit, our strategies for delivering vibrant businesses and a growing economy within this should be as flexible and innovative as we can make them. My sense is that the scope for new forms of business value is wide, in direct proportion to the scale and pace of the changes called for by the 2°C threshold.

Negotiating our way to a safe future for all in the face of climate change is, perhaps, a leadership challenge without precedent. We have to rise to this challenge to ensure the future of the generations to come.

The scope for new forms of business value is wide, in direct proportion to the scale and pace of the changes called for by the 2°C threshold.

Meinshausen, M, Meinshausen, N, Hare, W, Raper, SCB, Frieler, K, Knutti, R, Frame, DJ and Allen, M, 2009. 'Greenhouse-gas emission targets for limiting global warming to 2°C.' *Nature* 458, pp.1158–1162

The installation *Greenhouse Gas* was first realised in 2008 on an Arctic beach to which Sunand Prasad had voyaged with Cape Farewell. The valley had previously contained a glacier that has been lost, and Sunand Prasad used the vacated space to install four helium balloons, each tethered to the ground. The balloons delineated the area that equals the volume of one tonne of CO_2. This huge sculptural space represents merely the average monthly CO_2 emissions of each person living in the UK.

Ackroyd & Harvey's *Ice Lens* (2005) symbolises how the Arctic offered the artist duo a new world to engage with. The struggle to survive in the Arctic – shared by polar bears, whales, and all life, including the artists themselves when caught on board the sailing boat in a terrifying storm – resurfaced in several works created since their voyage. A polar bear's femur has been turned into a diamond; and the carcass of a beached whale was cut back to its bones, and then decorated with crystals grown upon the skeleton itself as an exquisite *memento mori*.

THE FUTURE IN PRACTICE
THE STATE OF SUSTAINABILITY LEADERSHIP

UNIVERSITY OF CAMBRIDGE
25 YEARS
PROGRAMME FOR SUSTAINABILITY LEADERSHIP

Section Three

Investigating the Future

The political economy of ecosystem services

Dr Bhaskar Vira

Ice Block Sound Installation by Max Eastley was realised in 2005 as part of the Cape Farewell open-air exhibition *The Ice Garden* in front of the Bodleian Library in Oxford.

The political economy of ecosystem services

Dr Bhaskar Vira

Dr Bhaskar Vira is a Senior Lecturer in the Department of Geography at the University of Cambridge, and led the Responses chapter for the UK National Ecosystem Assessment (UK NEA), published in 2011. He was Coordinating Lead Author for the Responses Working Group of the Millennium Ecosystem Assessment (MA), and is currently engaged in research funded by the UK Natural Environment Research Council, the Economic and Social Research Council, and the Ecosystem Services for Poverty Alleviation programme for the UK Department for International Development. Interview by Wayne Visser.

The past decade has seen a growing interest in ecosystem services, one of the focus areas of Dr Bhaskar Vira and his colleagues at the University of Cambridge's Department of Geography. Ecosystems services have been defined by landmark research projects like the Millennium Ecosystem Assessment and The Economics of Ecosystems and Biodiversity (TEEB) as "the benefits people obtain from ecosystems" and "the direct and indirect contributions of ecosystems to human wellbeing".

The Millenium Ecoystem Assessment, which ran from 2001 to 2005, synthesised the work of more than 1,360 experts worldwide and concluded that 60 per cent of world ecosystem services have already been degraded. TEEB emerged two years later from a meeting of environment ministers from the governments of the G8+5 countries in Potsdam, who agreed to "initiate the process of analysing the global economic benefit of biological diversity, the costs of the loss of biodiversity and the failure to take protective measures versus the costs of effective conservation".

With detailed analyses like those conducted by the MA, TEEB and the UK NEA, it is not surprising that ecosystem services have gained importance in policymaking, with several governments adopting management strategies based on the concept. There are at least three interrelated strands which characterise this emerging paradigm:

(i) the measurement of ecosystem service flows, and an emphasis on understanding the ecological processes underlying these flows, including the effect of these flows on human wellbeing;

(ii) the valuation of ecosystem services; and

(iii) negotiation over ecosystem services through a variety of institutional forms and governance mechanisms (which might include market-based intervention strategies, such as payments for ecosystem services).

Vira's research takes place within this broad ecosystems milieu, but from the perspective of the political economy of development, and with a focus on the impact of environmental policies on poverty alleviation in India. He builds on his long-term engagement with alternative models of forest governance in India, from state management and joint forest management to cooperatives, community management, and private forestry. He also has an interest in the social context of biodiversity conservation, especially focusing on conservation and wildlife management in India.

What makes Vira's work different and important is that he goes beyond the popular economics-oriented focus on the valuation of ecosystem services to recognise that natural resource use often takes place within

Figure 1: A political economy approach to ecosystems.

Vira goes beyond the popular economics-oriented focus on the valuation of ecosystem services, to recognise that natural resource use often takes place within a politically charged context. This approach is particularly relevant in India.

a politically charged context. He stresses: "It is vital to have an understanding of the political economy of negotiations over natural resource use. An appreciation of the synergies and trade-offs between ecosystem services is equally important for developing better strategies for pro-poor ecosystem management. If the distributional outcomes associated with alternative options for natural resource management are neglected, there is a risk that such interventions may fail because of resistance from those who are excluded or those who stand to lose."

This approach to ecosystem services is particularly relevant in India, where Vira grounds his research, and where the concept now features in policies and programmes for maintaining the quality of the environment and the sustainability of natural resources for the wellbeing of social groups across the country. A recent example is the National Mission for a Green India, approved by the Prime Minister's Council on Climate Change in February 2011. The mission derives its mandate from the National Action Plan on Climate Change (NAPCC) and aims at increasing India's forest cover by five million hectares, as well as improving a further five million hectares of degraded forest, over the next 10 years. One of its key objectives is the "improvement of ecosystem services, including biodiversity, hydrological services and carbon sequestration while also aiming to increase forest-based livelihood incomes for three million families".

Ecosystem management involves making difficult choices between different types of ecosystem services, and also between the competing claims of different groups in society. Trade-offs are often not adequately recognised and addressed, resulting in inequitable outcomes.

Despite the current emphasis on ecosystem services in India, Vira believes the country's policymakers and resource managers do not adequately recognise the importance of trade-offs. "There is considerable emphasis on understanding the biophysical aspects of ecosystem service provision and on refining economic valuation techniques to estimate the value of the services provided. Most interventions, whether participatory forest management, biodiversity conservation or watershed development, involve some form of restriction on existing patterns of resource exploitation to generate ecosystem services for other users. But while these interventions help to improve the condition of resources, they generally lead to a loss of livelihoods and development opportunities for at least some individuals or groups."

What Vira's research brings to policy debates like this is the increasing evidence that ecosystem management involves making difficult choices between different types of ecosystem services (such as climate regulation, biodiversity conservation, the provision of water or forest products, etc), and also between the competing claims of different groups in society (such as between local resource users and those within the global community concerned about climate change or the loss of key charismatic species). Patterns of demand, prices, institutional structuring of markets, and changing scientific knowledge are likely to make some services more valuable than others and change the balance between different users, leading to trade-offs. Such trade-offs are often not adequately recognised and addressed in policies and programmes, resulting in inequitable outcomes.

In the field, decisions typically involve iterative processes of consultation, negotiation and compromise. It is crucial for policymakers and activists alike to ask: How do conflicting stakeholders make choices in specific empirical situations? What are the relative roles of different actors and how do they exercise power in this process? Whose values and interests are reflected in final outcomes and to what extent can outcomes be seen to enhance social wellbeing? What are the institutions and structures of governance that enhance effective decision-making? These are difficult questions, but are critically important if improved ecosystem management is to be harnessed as a tool for sustainable poverty reduction.

A recent example of typical conflict over ecosystem services is between the provisions for critical tiger habitats, and the recognition of community rights under the Forest Rights Act (FRA) of 2006, which has revived old debates about choices between 'tigers or tribals'. The declaration of the Biligiri Rangaswami Temple (BRT) Wildlife Sanctuary as a tiger reserve, and the subsequent recognition of the community rights of the Soliga tribe in the sanctuary, highlights the nature of such conflicts. The sanctuary, which is home to more than 30 tigers, has been inhabited by Soligas for centuries. Under the FRA, their community forest rights have been recognised and they can collect, own and dispose of minor forest produce from the reserve. However, conservationists concerned about the declining tiger population have opposed this.

How do conflicting stakeholders make choices in specific empirical situations? What are the relative roles of different actors? Whose values and interests are reflected in final outcomes?

"The Indian political system must be ready to make tough choices... These choices are not technocratic or scientific, but political." Jairam Ramesh, former Indian Minister of State for Environment and Forests

The recent controversy surrounding forest clearances for industry and mining in India is another example of the classic environment-versus-economic development dilemma, and of how politics affect trade-off decisions. This involved the decision to scrap the nascent 'go and no go' strategy of the Union Ministry of Environment and Forests to protect particular ecologically sensitive coal-bearing areas.

The opening-up of forested Hasdeo-Arand in Chhattisgarh for mining is another prominent case in point. As Jairam Ramesh, former Minister of State for Environment and Forests, has commented, "the Indian political system must be ready to make tough choices and trade-offs between the objective of attaining economic growth of 9–10 per cent, and maintaining the ecological balance. These choices are not technocratic or scientific, but political."

Vira and his research colleagues argue that the real power of trade-off analysis in the ecosystem services context comes from its ability to bring diverse actors to the common recognition that hard choices are often the norm – one which is often not forthcoming when problems are framed as potential win-wins.

"We do recognise," says Vira, "that trade-off analysis is not in itself a panacea for better ecosystem management. But an explicit recognition of the distributional implications of policy choices improves the likelihood of equitable and just decision-making."

Vira, B, Adams, WM, Agarwal, C, Badiger, S, Hope, RA, Krishnaswamy, J and Kumar, C, 2012. 'Negotiating Trade-offs: Choices about ecosystem services for poverty alleviation'. *Economic & Political Weekly*, March 3, Vol XLVII no 9

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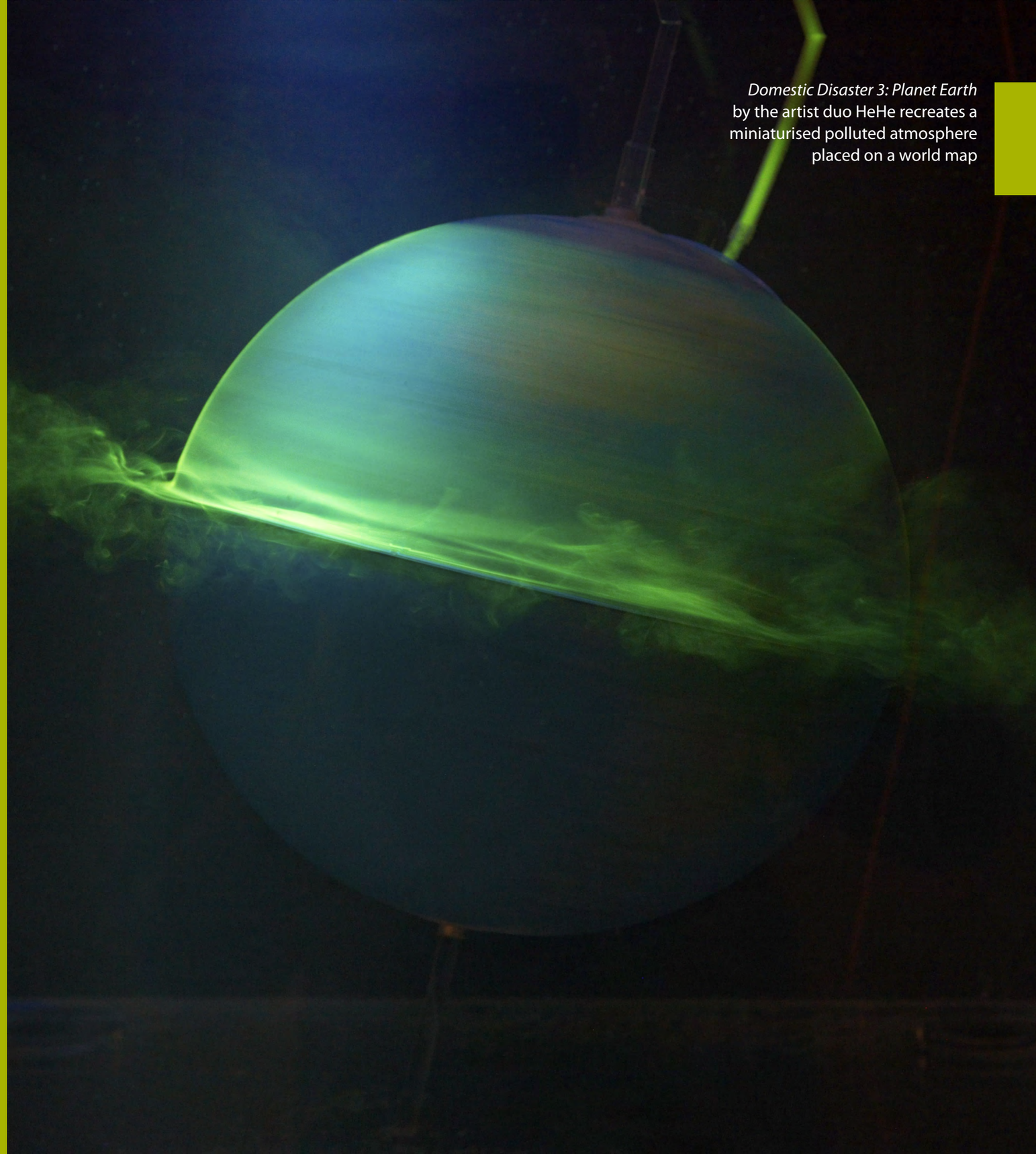
In this installation, drops of melting ice created an evocative soundscape when their fall stopped on metal slides placed below. The sound of the drops hitting the metal was amplified, reaching the corners of Clarendon Quad and of the audience's senses. This symbolic but playful work was created as part of the Cape Farewell project. Founded in 2001, Cape Farewell has engaged over 140 of our best creative minds in a deep, ongoing dialogue with almost 50 scientists.

Sustainable materials – with both eyes open

Dr Julian Allwood



Domestic Disaster 3: Planet Earth by the artist duo HeHe recreates a miniaturised polluted atmosphere placed on a world map

Sustainable materials – with both eyes open

Dr Julian Allwood

Dr Julian Allwood is a University Reader in the Department of Engineering, and leader of the Low Carbon Materials Processing Group. He is co-author of *Sustainable Materials – With Both Eyes Open* (2011). Interview by Wayne Visser.

The Intergovernmental Panel on Climate Change (IPCC) estimates that global greenhouse gas reductions of 50–85 per cent will be needed by 2050 to avoid dangerous climate change, representing a radical shift away from today's fossil-fuel-derived economy.[1] This begs the question: is such a reduction achievable, and if so, how? This is one of the key challenges tackled through the research of Dr Julian Allwood and his Low Carbon Materials Processing Group (LCMPG) at the University of Cambridge.

Allwood believes that we need to face the facts and find scalable solutions, rather than token gestures that make very little impact. In the opening chapter of his new book, *Sustainable Materials*, Allwood cites plastic grocery bags in the UK as a case in point. He notes that plastic accounts for about 1 per cent of the UK's CO_2 emissions, and plastic carrier bags make up 1 per cent of plastic use. Hence, even if all plastic bags were scrapped – and assuming their substitute were carbon neutral, which is unlikely – we would only be addressing 0.01 per cent of the UK's carbon footprint.

By contrast, says Allwood, "our aim is to look for solutions, and our number-one guiding principle is about scale – we want to make sure that we identify options for change that are big enough to make a big difference." Allwood's research team starts by quantifying which economic activities generate the most emissions. It turns out that 64 per cent of global CO_2 emissions are energy- or process-related (the rest are from deforestation, agriculture or decay); and 35 per cent of these emissions are from industry, 31 per cent from buildings and 27 per cent from transport.

In terms of buildings and transport, Allwood believes that there are still significant gains to be made from improved designs and technologies – perhaps as much as 75 per cent in energy savings. This is especially true for 'passive systems' which provide more final services for each unit of useful energy. He concludes that technical solutions for energy-efficient cars and houses are known, and their implementation depends on political will and public motivation. The same is not true, however, for industrial emissions, where many systems are already highly optimised, and where demand for materials is anticipated to double in the next 40 years.

For most materials used to provide buildings, infrastructure, equipment and products, global stocks are still sufficient to meet anticipated demand; but the environmental impacts of materials production and processing, particularly those related to energy, are rapidly becoming critical. In this case, it is not energy efficiency, but rather material efficiency that represents the biggest opportunity. Material efficiency – which essentially means delivering the same required services with less primary production – could allow greater cuts, at lower cost.

Here, too, it is important to focus on the biggest sources of impact, namely the five materials that contribute 55 per cent of global CO_2 emissions from industry and 20 per cent of global CO_2 emissions from energy use and industrial processes. Allwood's LCMP Group has predicted emissions scenarios to 2050 for five materials: steel, cement, paper, plastic and aluminium. Specifically, in their Reference scenario – which includes implementing all known and emerging best available technologies globally, raising recycling to the maximum possible, and securing 20 per cent decarbonisation of all energy – industry still fails to deliver the minimum 50 per cent emission cuts required by the IPCC.

Based on an analysis of strategies to improve material efficiency in these five key materials, Allwood's LCMP Group have created a 'Material Manifesto', which includes the following six actions to make the future of materials use more sustainable.

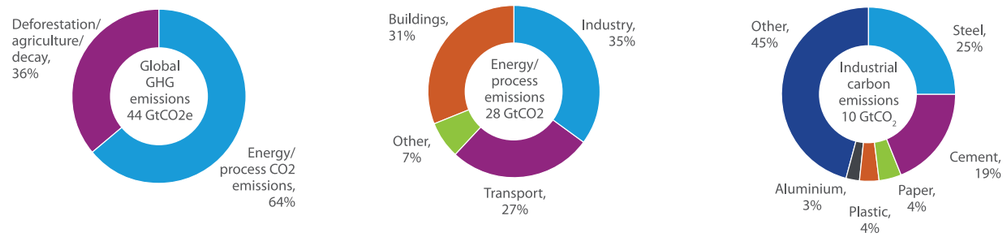


Figure 1: Sources of global CO_2 emissions. from *Sustainable Materials – With Both Eyes Open.*

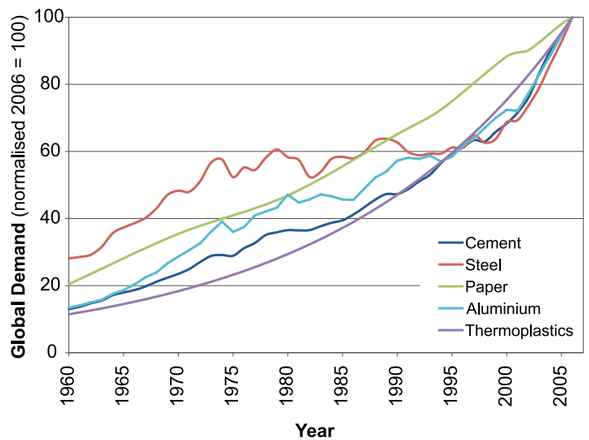


Figure 2: Normalised global demand for the five key materials since 1960, from Allwood et al, *Environmental Science & Technology* 2010, 44, 1888–1894.

1. Use less metal by design

We could make big savings by optimising the design of metal components. The materials used by industry are often designed in a regular shape to make production easier and more efficient. But this means that they often use more material than they have to. The researchers calculate that if we can optimise beam designs, for example, to suit their use, we could make weight savings of up to 30 per cent – with a similar reduction in the emissions caused by production. Similar techniques could be applied to the production of components for cars, the 'rebar' used to reinforce concrete, and steel cans for food storage.

[1] Keeping the concentration of CO_2 equivalents in the atmosphere between 445–490 parts per million with a corresponding average global temperature increase of between 2.0°C and 2.4°C

"When you take a building down, the steel girder is totally reusable. All you need to do is unbolt it and clean it, because steel doesn't degrade with use."

2. Reduce yield losses

At least 25 per cent of liquid steel and 40 per cent of liquid aluminium never makes it into products. Instead, it is cut off as scrap in manufacturing. One extreme example is the aluminium wing skin used for aeroplanes: 90 per cent of the metal produced in this process ends up as 'swarf', or aluminium scrap. The researchers found that this is often the result of habit, rather than necessity. Clothing manufacturers have, for example, actually derived the algorithms needed to make sure that rolls of fabric are used to maximum effect. Manufacturers could do the same thing with the metal they receive. The team calculated that reducing yield losses through this and other techniques would cut CO_2 emissions by about 16 per cent in the steel industry and 7 per cent in the aluminium industry.

3. Divert manufacturing scrap

Scrap metal is usually sent for recycling, which means melting it (an energy-intensive process). In fact, it could just be used elsewhere. For example, most steel scrap comes from 'blanking skeletons' – the remains of sheets of steel after shapes have been cut out of them. About 60 megatons of steel are scrapped on this basis every year. We could effectively reduce scrap steel by half if these skeletons went to the manufacturers of smaller components instead, who can use what's left.

4. Re-use old components before recycling at all

Old components are often recycled when they could be re-used directly instead. Car dismantlers are an example of good practice, breaking up damaged or old vehicles and re-using the components. But steel in construction remains the biggest potential asset, and although the beams from dismantled buildings are usually recycled, they could often be used again straight away instead. "When you take a building down, the steel girder is totally reusable," Allwood says. "All you need to do is unbolt it and clean it, because steel doesn't degrade with use. Re-use means we can avoid all the energy of melting, casting and re-rolling old steel."

5. Extend the lives of products

Most demand for products in developed economies isn't to expand the overall stock, but to replace existing items. Fridges are a good example – we still need them but in the UK we destroy 33 per cent more fridges every year than we make cars. The researchers advocate modifying products rather than replacing them wholesale, and urging manufacturers to develop adaptable designs that would help this process. This requires a change in thinking and an end to planned obsolescence.

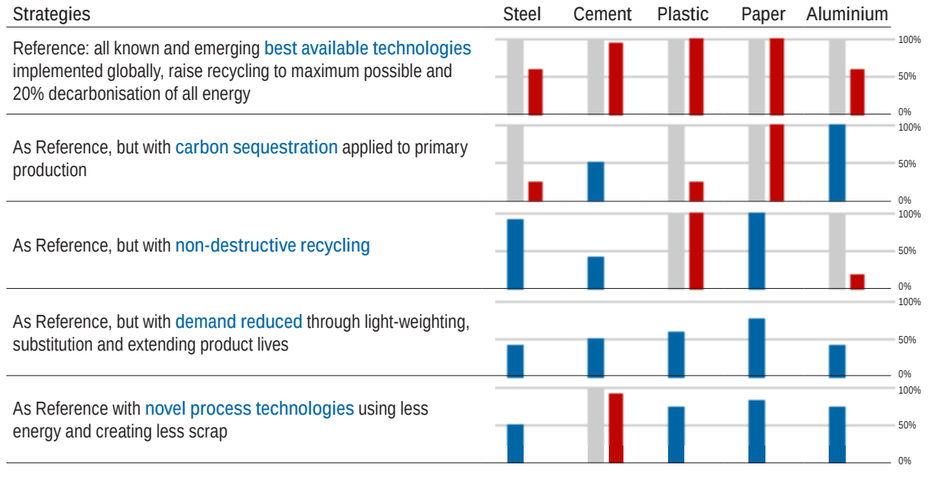


Figure 3: Predicted 2050 emissions for the five key materials under various future strategies. The blue bar shows how extensively the strategy must be implemented to reach the IPCC target. If 100 per cent implementation is insufficient, the red bar shows the excess emissions relative to the target.

6. Reduce final demand

The fall-back option that no policymaker would ever condone, except in times of war, is to reduce final demand. Yet it remains the case that we could be living with less stuff overall. In the UK, for example, we each spend 225 hours per year in the car. We have 28 million licensed cars with, on average, four seats in each. There are 60 million people. So each car seat is, on average, in use for 2 per cent of the year. We could reduce our overall stock to 7 million cars with ease. This is, of course, scuppered by the convenience factor of having a car when we need it. We may not want to make these changes to our convenient lifestyles, but that is not to say that we couldn't do it if we needed to.

In industrialised nations, material efficiency strategies have had little attention, mainly because of economic, regulatory and social barriers. However, evidence from waste management and the pursuit of energy efficiency suggests that these barriers might be overcome. Critically, however, different strategies are not equally effective for different materials. For instance, non-destructive recycling may have the most potential for steel and paper, while novel process technologies may be more appropriate for plastics. In general, reducing demand through light-weighting, substitution and extending product life appears to be a strong strategic option across the five materials.

Reflecting on his group's ambitious research programme, which resulted in the publication of *Sustainable Materials*, Allwood concludes: "We wanted to consider whether we could cut emissions by reducing the amount of stuff produced in the first place. Every aspect of our lives today depends on materials like steel and aluminium. If we want a sustainable future, we need to reduce the impact of producing them, and our biggest option for achieving this is to reduce our thirst for new material."

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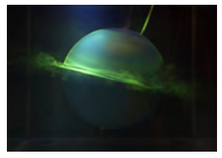
Allwood, JM, Ashby, MF, Gutowski, TG and Worrel, E, 2011. 'Material efficiency: a white paper'. *Resources, Conservation and Recycling* 55 (2011) pp.362–381

Allwood, JM, Cullen, JM and Milford, RL, 2010. 'Options for Achieving a 50% Cut in Industrial Carbon Emissions by 2050'. *Environmental Science and Technology* 44, (2010) pp.1888–1894

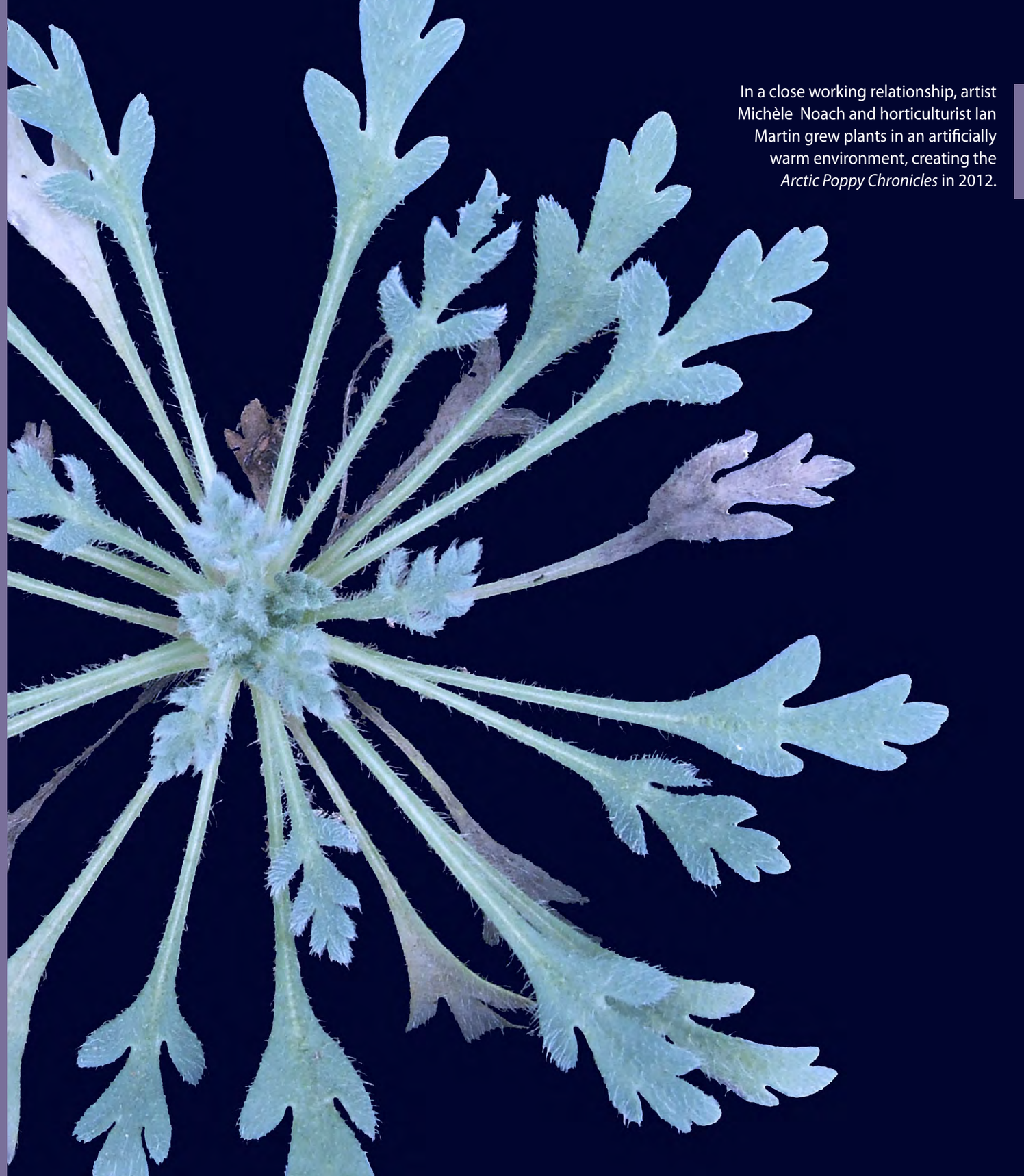
Cambridge Research News, 2011. 'Six steps to a better material world'. 30 November. http://www.cam.ac.uk/research/news/six-steps-to-a-better-material-world/



The artist duo HeHe, formed by Helen Evens and Heiko Hansen, create with *Domestic Disaster 3: Planet Earth* (2012) an unsettling installation, full of beauty and menace. Colourful and artificial, animated by a slow movement and accompanied by a sound choreography, this atmosphere echoes the research on fluid dynamics led by Jean-Marc Chomaz (CNRS, Laboratoire LadHyX, France). The work was commissioned for the Cape Farewell exhibition *Carbon 12: Art and Climate Change*.

A 'doubly-green' revolution

Professor Chris Gilligan



In a close working relationship, artist Michèle Noach and horticulturist Ian Martin grew plants in an artificially warm environment, creating the *Arctic Poppy Chronicles* in 2012.

A 'doubly-green' revolution

Professor Chris Gilligan

Professor Chris Gilligan is Head of the School of Biological Sciences, Professor of Mathematical Biology and Head of the Epidemiology and Modelling Group at the University of Cambridge. He is also Chair of CPSL's Management Board. Interview by Wayne Visser.

According to the latest figures by the UN Food & Agricultural Organisation, 13 per cent of the world's population is undernourished, including 33 per cent of the population of the least developed countries. Furthermore, the world faces a potential food crisis in coming decades as the population grows inexorably and as climate-related changes intensify pressures on food production. Given that the most productive land is already being used around the globe, simply increasing crop production is not the answer.

One way to safeguard food security is to increase the yield of crops from the same amount of land, while also minimising the amount lost to pests and pathogens – the so-called 'untaken harvest'. Outbreaks of disease can sometimes reach epidemic proportions, wiping out entire crops, often with substantial social and economic consequences. Today, epidemics such as cassava mosaic disease, citrus canker, and a particularly alarming new wheat pathogen, Ug99, threaten important agricultural and food crops in regions across the globe.

This is the area on which Professor Chris Gilligan's research focuses. He believes that global food security is one of the major challenges we face in the 21st century.

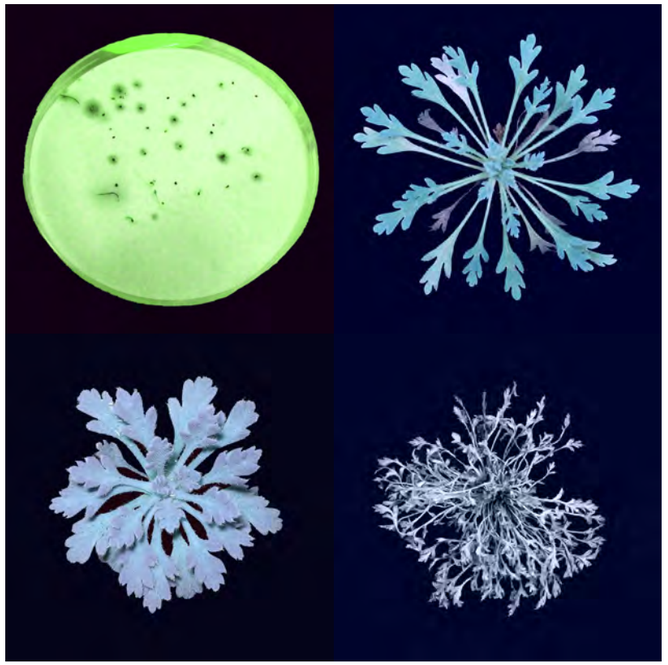
"Each year, despite remarkable improvements in crop-protection strategies such as breeding disease resistance, a quarter of the global crop production is still lost in the untaken harvest, and plant pandemics are a constant threat," he explains. "One way, amongst others, to reduce these losses is to develop mathematical models that can help regulators, policymakers and growers to track disease and develop surveillance and eradication strategies."

This is precisely what Professor Gilligan and his team of mathematicians and statisticians have developed during his tenure of a Biotechnology and Biological Sciences Research Council (BBSRC) Professorial Fellowship. Their mathematical toolkit not only provides a new way of predicting the risks and hazards associated with crop production, but also, crucially, generates intelligence on the cost-effective management and control of that threat.

Gilligan's research helps to identify epidemiological strategies that minimise the risks of failure of chemical and genetic control.

The economic and social benefits of food security through disease control are clear. However, Gilligan also sees effective epidemiological control as part of a 'doubly-green' revolution to increase yields but to do so sustainably. This involves integrating research expertise in the natural, clinical and social sciences with insights from the humanities, to develop tractable solutions that are sustainable, socially equitable and ecologically successful.

"Each year, despite remarkable improvements in crop-protection strategies, a quarter of the global crop production is still lost, and plant pandemics are a constant threat."



For Gilligan and his team, in practice, this does not mean banning chemical or genetic controls of plant disease, but rather ensuring that their effectiveness and impacts are well understood and carefully managed. This is why his research helps to identify epidemiological strategies that minimise the risks of failure of chemical and genetic control. In many cases, this allows for more selective, intelligently targeted and locally applied controls, resulting in an overall lower negative impact on humans and the environment.

The goal of resilience

One of the central aims of Gilligan's research is to increase the resilience of our agricultural – and associated biological, scientific and human – systems. This critical element of sustainability is only possible when we are better able to model and respond to uncertainty.

In the case of the invasion and persistence of a disease, working out where to look for it and how frequently, and then predicting what will happen and how best to control it, can be fraught with challenges. Not only can the scale of an epidemic be hidden – for instance some infected plants might be symptom-free and yet transmit infection – but, as Gilligan explains, there is also an element of uncertainty in how infection is transmitted.

"Dealing with complicated systems that have a biological, economic and social component is inevitably challenging. In addition to this 'noise' is the potential for the disease to take what you might imagine to be an unlikely turn. The art of modelling is to identify as simple a model as possible that captures

Gilligan sees effective epidemiological control as part of a 'doubly-green' revolution to increase yields, but to do so sustainably. This involves integrating research expertise in the natural, clinical and social sciences with insights from the humanities.

the inherent features of the system, and then to use it to explore the likelihood of disease spread, allowing for uncertainties."

As the Cambridge scientists have discovered, the secret has been to allow many possible scenarios to play out through the model. Bayesian methods of statistical inference are used to allow for uncertainty in understanding how an emerging epidemic spreads, and the model is then updated as new data become available. This allows the group to predict the most likely future spread of disease based upon current knowledge.

Working in collaboration with the UK Department for Environment, Food and Rural Affairs and the United States Department of Agriculture, Gilligan's group has successfully integrated a fundamental biological understanding of how certain diseases spread with epidemiological models that incorporate data from geographic information systems about landscape and weather. The result is a toolkit that enables end-users to identify the risks and hazards of disease detection, spread and control. Supported by the Gates Foundation, Gilligan's group is now applying these methods to analyse strategies for the control of plant disease in African agriculture.

Improving decision-making

Any form of disease control involves costs and crucial decision-making. Where mathematical modelling can help is in enabling regulators to use resources strategically in the most effective way.

One recently published report from the team looked at Asiatic citrus canker, a bacterial disease of the economically important citrus crop of the USA, Brazil and Australia. Eradication attempts have already proved to be extremely costly – a decade-long attempt in Florida which began in 1995 cost in excess of $1 billion and led to the removal of millions of citrus trees.

The new results flagged up an important point, which informs a political dilemma concerning the removal of diseased trees to eradicate the disease when the pathogen infects both residential and commercial trees. The two constituencies, home owners and growers, are linked by dispersal of the pathogen, and what happens in one constituency affects the other. Hence, an eradication effort must be co-ordinated in both areas.

"It is precisely this type of intelligence about disease dynamics that is so important for regulatory bodies to be aware of," explains Gilligan. "With this knowledge, it would be possible to choose a control strategy that satisfies the objectives of both commercial and residential citrus tree owners."

Often the recommendations of the models are counter-intuitive. "Contrary to expectations, for some diseases, the best strategy is to operate an intermediate level of detection rather than a high level of vigilance," he says. "In fact, even a slight change in the balance between the resources allocated to detection and to control may lead to drastic inefficiencies in control strategies."

For some diseases, the best control method for an outbreak in two regions is to control the smaller outbreak first and then to concentrate on the larger one. "The common assumption would be to try to equalise the level of infection in both regions by first tackling the larger outbreak, but for some diseases this is the worst you can do – much better to concentrate resources on eradicating them in the region with the lower infection," explains Gilligan. "The models allow us to identify where best to deploy control, and where there would be wasted effort."

Because the underlying mathematics and epidemiological modelling are similar regardless of the disease, the toolkit can also be targeted towards the surveillance of human diseases.

"We don't yet know when Ug99 will arrive in major wheat-growing areas such as Europe and the Indian subcontinent… When the pathogen arrives, we need to be ready, and this means having the capability to detect, track and control the disease effectively."

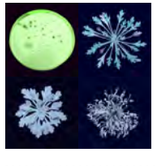
Anticipating the future

The models have not only been used for studying plant pests and pathogens, but also to study the spread of pesticide resistance, and the transfer of genes from genetically modified crops to wild populations. And because the underlying mathematics and epidemiological modelling are similar regardless of the disease, the toolkit can also be targeted towards the surveillance of human diseases and pandemics.

A key aim of the research programme has been to develop a resource within which end-users can easily try out and simulate a range of control scenarios – adjusting parameters such as how often surveys are conducted, how successful detection is, what level of eradication is aimed for, and which control strategy to use.

Gilligan anticipates one particularly important use for the toolkit in the near future: a new strain of the wheat pathogen called stem rust, Ug99, emerged in Uganda in 1999 and has been spreading north, across the Red Sea and into the Middle East. "We don't yet know when it will arrive in major wheat-growing areas such as Europe and the Indian subcontinent, but we are at least five years away from having a wheat variety that can resist the pathogen. When the pathogen arrives, and it is very likely that it will, it could inflict severe shortages in wheat production, costing billions of pounds. We need to be ready – and this means having the capability to detect, track and control the disease effectively."

Gilligan's research approach embodies much of what has come to be understood as sound principles of sustainability – understanding problems systemically and applying context-specific solutions; anticipating future threats and preparing solutions to cope with them; thinking about the long-term consequences of our short-term actions; using cross-disciplinary skills and knowledge to solve interconnected, multi-level problems; embracing new technology while remaining conscious of its risks; and applying scientific progress to serve people and the planet rather than catering only to narrow economic interests.



Michèle Noach developed *The Arctic Poppy Chronicles* throughout her artist residency as part of the 'Slow Art' programme at the Eden Project. Meticulously documenting the poppies' adaptive capabilities in a rapidly warming environment, she worked alongside Eden horticulturist Ian Martin as they grew and observed the poppies over a 3-year period. The poppies' survival inspired a thrilling working relationship between artist and scientist, creative and rigorous in equal measure, which was published as *Poppyflakes*.

Perspectives on carbon capture and storage

Dr David Reiner

In 2005, architect Peter Clegg and visual artist Antony Gormley collaborated on temporary sculptures, *Three Made Places*, whilst on a Cape Farewell expedition to the High Arctic.

Perspectives on carbon capture and storage

Dr David Reiner

Dr David Reiner is a University Senior Lecturer in Technology Policy at the Judge Business School. He is also Director of the MPhil in Technology Policy, Assistant Director of the Electricity Policy Research Group, and a member of the Coordination Group of the UK CCS Research Centre with responsibility for social sciences and public communications. Interview by Wayne Visser and Francesca Raphaely.

Dr David Reiner's research follows international negotiations on climate change, the consequent development of national climate change and energy policies, and public perception and communications regarding energy and climate policies. Much of his research focuses on regulatory design in energy and environmental policy, such as in setting goals in regulation and on wider public attitudes towards energy – for example, the upcoming rollout of smart meters and its likely impact on consumer demand.

A particular interest for Dr Reiner is carbon dioxide capture and storage (CCS) – a technology which could play a significant role in addressing the CO_2 problem, but which also has become a source of controversy. He has led several research projects exploring how CCS is perceived among different environmental activists, and how the energy industry, environmental activists, and the lay public communicate about CCS. Two recent studies were sponsored by the Global CCS Institute through the Australian Commonwealth Scientific and Research Organisation (CSIRO) and completed in June 2011.

Why CCS?

Carbon dioxide capture and storage is one of the only technologies capable of reducing the amount of CO_2 in the atmosphere, rather than just slowing accumulation; yet it has generated disagreements both within the environmental movement and at the local community level. Reiner neither supports nor opposes CCS. Rather, he says, "All scientists look for gaps in knowledge", and when he began his research in 2002, public understanding of CCS was so limited it offered the possibility of establishing a 'baseline' against which he could measure any changes. In addition, he believes that CCS provides an interesting case for insight into the wider climate debate.

Carbon dioxide capture and storage is one of the only technologies capable of reducing the amount of CO_2 in the atmosphere, rather than just slowing accumulation.

The first public controversy over CCS dates back to the earliest projects, initiated in the late 1990s. The first of these, an initiative planned by the US, Japan, Norway and Canada to store carbon dioxide in waters off the coast of Hawaii, the so-called Ocean Sequestration Field Experiment, focused purely on technical challenges. It failed to account for local interests concerned with protecting the marine environment as a tourist attraction, and it also neglected sensitive political considerations. Most basically, time and resources had not been built in to engage with public concerns.

As a result, the initiative became mired in objections and bureaucratic red tape. A relocation to Norwegian waters was planned, but this became a campaign target for Greenpeace and the project was ultimately cancelled. Since then, there have been no further efforts at storing CO_2 in the oceans and since 2000, storage projects have only focused on geological formations, either deep onshore (many hundreds of metres below the surface) or offshore (under the seabed in the North Sea, for example).

"That series of unfortunate, or badly managed, events ended up taking all of ocean CO_2 storage off the table, without really thinking, without public debate, without considering the consequences," says Reiner. It is a case in point of how technical solutions cannot be judged solely on technical merit, and will only succeed with buy-in from decision-makers and the general public.

"A series of unfortunate, or badly managed, events ended up taking all of ocean CO_2 storage off the table, without really thinking, without public debate, without considering the consequences."

Debates around CCS also highlight some challenges around the wider climate debate, as Reiner's research into the views of environmental activists demonstrates.

Radical environmentalists and CCS

After international climate negotiations in Copenhagen in 2009 failed to establish new binding emissions reduction targets, Reiner set out to explore whether this perceived breakdown would lead to greater activism or even radicalism. He and his collaborator Olaf Corry explored the attitudes of radical environmental activists to CCS, by attending 'Climate Camps' in several countries. These events were coordinated by a loose coalition of smaller environmental NGOs and grassroots movements, and were designed partly to educate and prepare activists for direct action.

Reiner's main finding was that CCS is not judged primarily on technical grounds among this group. Instead, environmentalists based their evaluations on what role they believed CCS would play in society. More specifically, the main concerns and questions about CCS related to:

- **Perceived opportunity costs** – Will it divert resources away from renewable energy and prolong our reliance on fossil fuels, thereby perpetuating existing industrial structures?
- **Implementation** – Will it happen, and will it happen fast enough to make a difference in combating climate change?
- **Monitoring** – Can we trust those charged with CCS to do it properly?

Although more than half of the activists surveyed thought CCS could reduce CO_2 emissions, it was given extremely low priority compared to other options to address climate change, such as renewable energy and reductions in energy demand.

The voidshelter of *Three Made Places*, illuminated at night.

Among 'Climate Campers', Reiner's team found that questions about CCS had an interesting effect. "If you talk to most environmentalists about nuclear, or renewables, or coal, it's easy. Then you ask them about CCS and it starts to get harder, because it starts to raise the issue of what the real problem is. Is your real concern global climate change, or is it centralised power generation? Or is it the way our industrial civilisation is structured?"

The radical environmental movement offers a loose umbrella for campaigners from a variety of positions, Reiner found. "Carbon dioxide emissions motivated a number of the people there, but others saw this as a reflection of a much broader social debate."

CCS highlights the divergences in these positions, because it is how it would be used that would determine its impact. Many point out that CCS could preserve the 'status quo' of fossil fuel reliance, offering an easy way for the energy industry to maintain harmful extractive practices while using CCS as a 'fig leaf'. On the other hand, others appreciate that, if implemented alongside biomass generation, CCS could actually enable energy production with negative overall emissions, thereby offering deeper CO_2 cuts than renewables alone.

CCS is not judged primarily on technical grounds among environmentalists. Instead, they base their evaluations on what role they believe CCS would play in society.

In fact, says Reiner, differences of opinion among radical environmental activists have now led the Climate Camps to be disbanded, as organisers could not reach a consensus on how to work towards their quite disparate goals. The responses to CCS lead Reiner to comment that some issues in the climate debate, such as renewable energy, are 'overdetermined': people have numerous reasons for supporting a solution, which allows those with often antithetical views to come together to support emissions reductions. Moving beyond easily agreed solutions to more nuanced issues such as CCS reveals fissures within the movement, exposing the fundamental differences – for example, between those who believe that the chief problem of our time is climate change, and those who believe it is capitalism.

CCS and Green Party activists

To "get the other side of the equation", Reiner then conducted similar research among Green Party activists – campaigners involved in the mainstream political process – at party conferences in Edinburgh and Cardiff.

He found that this group was more positive than 'Climate Campers' about the potential for CCS. While 84 per cent of 'Climate Campers' had said they would 'probably not' or 'definitely not' use CCS alongside coal-fired energy generation, only 40 per cent of 'Greens' took the same position. (In each group a similar proportion – roughly two-thirds – were in favour of using CCS alongside biomass, since that would result in net negative emissions.)

"The people who are willing to be involved in the political process, I think, are the ones who are more willing to accept constraints that we all operate under," Reiner comments. "They are playing by the rules; the nature of politics is trade-offs. You might still have a very strong opinion, but you accept those trade-offs."

CCS highlights the divergences in environmentalists' positions, because it is how it would be used that would determine its impact. CCS could preserve the 'status quo' of fossil fuel reliance… or, if implemented alongside biomass generation, it could actually enable energy production with negative overall emissions.

This highlights the contrast between the way environmental issues are debated among NGOs, which are relatively divided in their positions, and among political players, who are keen to achieve action and consensus. Yet strikingly, Reiner found that politicians are among the least trusted sources of climate change information, for both Green Party members and 'Climate Campers'. Corporate scientists and the energy industry were also highly mistrusted, with the greatest hostility among 'Climate Campers' directed towards large corporations.

In contrast, NGOs are among the most trusted sources of information among environmental campaigners of both types, but they have generally remained neutral on CCS, ranging from moderately sceptical to largely positive. Non-industry scientists were also perceived as trustworthy sources of information, but, naturally enough, few of these are concerned with the wider context of how CCS is implemented, focusing more on technical issues.

Although well disposed towards scientists because of the contribution of peer-reviewed science in raising awareness of climate change, both 'Climate Campers' and Green Party members focused on social and systemic issues rather than technical ones. In Reiner's surveys, few believed that technology would play a 'leading' role in dealing with the worst effects of climate change. System-wide problems such as climate change and resource depletion were seen as more important than traditional 'local' environmental issues such as air and water pollution, or protecting endangered species – showing how the environmental debate has moved on to a wider critique of existing norms.

Communicating CCS

This lack of engagement by the most trusted sources – NGOs and independent scientists – with the questions that most concerned activists led Reiner to look more closely at the way CCS is discussed in the public sphere. He conducted two pieces of desk-based research in 2008 and 2011, and found that the CCS ambitions of governments and other leading institutions have grown steadily in the interim, as have funding commitments. But existing communications remain far from adequate, given the level of governmental and business interest in the technology.

Reiner found that CCS communication was more extensive by 2011, was better co-ordinated and made greater use of a variety of media. However, it remains in need of greater interactivity and attention to the needs of end users, including more diversity in language and approach.

CCS communication also tends to be heavily oriented towards explaining the technological and engineering processes involved. Socio-economic questions about costs, burdens, policy alternatives and wider implications – all concerns raised by activists – receive much less coverage. To communicate more effectively with a wider audience, more attention is needed to explain how developing CCS would affect other long-term problems apart from climate change, and how CCS compares to other options.

Reiner found that a mix of government, industry, NGO and research institutions now communicate CCS as an integrated technology, looking at the wider issues of how it would be implemented alongside other energy-generation technologies. More information sources are appearing, but websites which describe CCS, especially from NGOs and research organisations, can stagnate or disappear. Different target audiences need

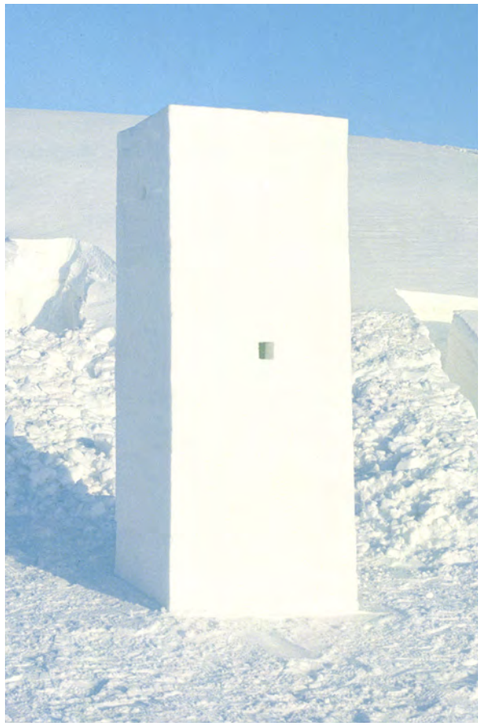
"Is your real concern global climate change, or is it centralised power generation? Or is it the way our industrial civilisation is structured?"

"The Web is used almost entirely as a loud-hailer – as a way of saying even louder what people would be saying otherwise. There's no real discussion, no real sense of engagement."

different messages, types and levels of information, and these are currently not always available. Educational materials are being developed, but slowly.

In contrast to the patchy coverage from trusted NGOs and non-industry experts, the most prevalent communications come from less-trusted sources such as business and governments, which often are CCS advocates. The majority of this material is overtly positive, without addressing the challenges levelled against CCS. While more trusted NGOs and critical sources tend to focus on a wider set of issues – emphasising cost, burdens and social implications – communications by research institutions, which are also considered trustworthy, are usually narrowly technical, and fail to acknowledge the existence of wider concerns.

Challenges around the transport of CO_2, in particular, have been neglected. This is a key issue to the public, and, again, raises many different challenges depending on where and how CCS is implemented. In the UK, for example, the potential for CO_2 storage is offshore under the North Sea, which means pipelines would need to be constructed to transport CO_2 from the sources of energy generation to the coast. In terms of public responses, says Reiner, this means that "if your plant is right by the coast, your 'footprint' to deal with the public is really quite small; whereas if you're by Doncaster and you need to get to the North Sea, it will require a hundred or so miles of pipes." This means addressing similar issues to those around the construction of a gas pipeline: obtaining consent and right of way, dealing with concerns about the landscape, etc. In contrast, for CCS projects in continental Europe further from the coast, 'onshore' carbon storage near energy generation has raised its own fears among the public and a good deal



of so-called 'not-under-my-back-yard-ism'. This has led to onshore projects in Germany and the Netherlands failing because of public opposition. It is this lack of attention to the public-relations 'footprint' that concerns Reiner.

While there is considerable coverage of CCS on the Internet, Reiner also notes that this is almost entirely one-way and top-down, with little opportunity for discussion or reaction. "The Web is used almost entirely as a loud-hailer – as a way of saying even louder what people would be saying otherwise. There's no real discussion, no real sense of engagement."

The future of CCS

Reiner's exploration of public perceptions of CCS highlights schisms and impasses in the environmental movement; the limits of scientists' and engineers' ability to implement solutions once they have been formulated; and how distrust can reach such high levels in the climate debate that any sort of progress is precluded. He is also concerned that government policy and incentives to support the technology remain weak, leading to inadequate investment in CCS.

Given that most distrust around CCS is due to claims that it preserves the interests of the energy industry, says Reiner, it's ironic that this sector has invested so little in engaging in debate. This lack of attention to addressing concerns around CCS is "striking, particularly for an industry that is in the business of siting infrastructure that's difficult to site. I always find it almost amusing that I need to explain to large multi-nationals how to do this better.

"If CCS is essentially meant to perpetuate the existence of the energy industry, they really aren't taking it seriously enough. They take the technical issues seriously, and you have wonderful people who are trying to improve the science. But there's almost nothing on the 'softer' side of things." Energy interests, comments Reiner, have technical expertise in implementing large infrastructure projects, combined with the experience and funding

The environmental debate has moved on to a wider critique of existing norms.

to run public campaigns on controversial issues and engage with local communities. In contrast, scientists, who are more trusted as a source of reliable information, have neither the experience nor the resources to participate in public dialogue on the subject.

"It is true that engagement and developing a discussion takes longer. Engaging with independent scientists and NGOs will take longer. But, by the same token, it's not like we're rushing into this either. Given that progress has been so slow, it's almost unconscionable that this hasn't happened."

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On Cape Farewell's third art and science voyage in 2005, with their boat locked into Arctic ice, architect Peter Clegg and artist Antony Gormley collaborated on the construction of *Three Made Places*. Carved into the vast white landscape, the configuration is at once monolith, shelter, and sarcophagus. According to Peter Clegg, "One kilo of CO_2 at atmospheric pressure occupies $0.54m^3$. That is the space – approximately – taken up by ourselves and the space immediately around us. It is roughly the volume of a coffin, which is perhaps an appropriate symbolic unit when we are talking about the destruction of the planet."

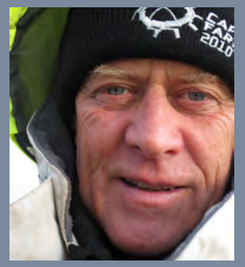
Section Four

Imagining the Future

David Buckland

A simple and undeniable truth

UNIVERSITY OF CAMBRIDGE
25 YEARS
PROGRAMME FOR SUSTAINABILITY LEADERSHIP



A simple and undeniable truth

David Buckland

David Buckland, *Pregnant Woman* (2008): The shadowy form of a pregnant woman is projected over black Arctic ice – an image loaded with the danger of trapped carbon, but conveying the full potential of our planet's future generations.

A simple and undeniable truth

David Buckland

David Buckland is a designer, artist and film-maker whose works have been exhibited in numerous galleries worldwide. He has published five books and two monographs of his work. In 2001 David Buckland created and now directs Cape Farewell project, bringing artists, scientists and educators together to collectively address and raise awareness about climate change. The works generated by these endeavours have led to a range of outcomes, including two major internationally-touring exhibitions, the publication of several books, and the production of two films. www.capefarewell.com

Storytellers, CS Lewis said, carry meaning in a way that rational truth-tellers cannot. "For me," the novelist wrote, "reason is the natural organ of truth; but imagination is the organ of meaning. Imagination, producing new metaphors or revivifying old, is not the cause of truth, but its condition."

A pregnant woman is projected onto a glacial wall of ice in Greenland high in the Arctic. The woman's body and mind are nurturing the growing foetus within her body, it is probably her primary focus and soon a new life will be born. Within 20 years, when the baby is grown into an adult, the glacial ice of the high Arctic will have largely disappeared. The baby has been nurtured, but have we abandoned any notion of care for its habitat?

For the past 12 years, the Cape Farewell project has embedded climate scientists with artists, writers and film-makers to address what has been described as humanity's greatest challenge: anthropogenic climate change. The two intellectual tribes of scientists and artists have been surprised at the closeness of their shared quest to define how we can comprehend the complexities of the climate challenge. Both have benefited from each other's ambition to envision a cultural shift that could lead towards sustainable societies.

The scientific evidence is clear: our climate is changing at an unprecedented rate, and in damaging and potentially irreversible ways. Yet even as we witness the impact of 'crazy weather' (droughts, floods, storms) on food production and habitat, and watch it place additional stresses on global health and economies, it seems that both the media and public debate have become quieter on the issue of climate change. The larger collective will is to simply ignore the proverbial elephant in the room.

David Buckland, *Baby on Ice* (2008)

The urgency isn't being communicated successfully enough to provoke the real change in our societies around the globe which is needed to reduce greenhouse gas emissions and mitigate climate change. Our resistance to engaging with change is baffling, in the face of the extreme weather events and other disturbances across our planet. Anthropogenic climate change threatens us all with an uncertain physical, social and economic future, so why are we not engaged in sorting out our future?

The two intellectual tribes of scientists and artists have been surprised at the closeness of their shared quest to define how we can comprehend the complexities of the climate challenge.

Perhaps cultural approaches can succeed where the hard facts of science have failed. So far, Cape Farewell has made seven expeditions into the Arctic aboard the 100-year-old Norwegian schooner, *Noorderlicht* (Northern Lights); one expedition to the Andes and the Amazon; and one to the Scottish Western Isles. Each of these journeys allows the diverse expedition teams – scientists, artists, creative thinkers – to examine how anthropogenic activity is affecting our habitat.

"The pressure of our numbers, the abundance of our inventions, the blind forces of our desires and needs are generating a heat – the hot breath of our civilisation. How can we begin to restrain ourselves?" wrote novelist Ian McEwan, after visiting the melting Arctic ice on a Cape Farewell voyage. "We resemble a successful lichen, a ravaging bloom of algae, a mould enveloping a fruit. We are fouling our nest, and we know we must act decisively, against our immediate inclinations. But can we agree among ourselves?"

The story of Cape Farewell

The initial aim of Cape Farewell was to create a different language of climate change with which to engage the public. Over 140 arts-based practitioners have taken part in these voyages, collaborating with more than 45 scientists to challenge the central question of our time. This international effort includes people from China to Mexico, bringing distinctly different cultural sensibilities to the story of climate change's causes and impacts.

The wide range of material produced is testimony to the success of this enterprise, including exhibitions (such as at the Natural History Museum and Royal Academy of Arts in London), films (such as the BBC's *Art from the*

The lens of the Cape Farewell project has shifted from looking at causes to mapping solutions... What we need now is human-scale solutions to global concepts.

Arctic, and *Burning Ice* for Sundance Television, USA) and writing (including McEwan's novel *Solar*). Since the project began in 2001, the creative climate language has now been established, and in Europe the public now accepts the fact of climate change. The lens of the Cape Farewell project has shifted from looking at causes to mapping solutions.

The story of the cure of rabies provides a striking metaphor. Doctors resisted this deadly virus by doggedly defending the nervous system as it is attacked, and, in so doing, broke the resistance of the virus. What if, instead of trying to climb the mountain and produce an all-encompassing global treaty on climate change, we used the already existing tools at our disposal?

2010 Arctic Expedition, Svalbard

At the UN climate meeting in Copenhagen in 2009, which ended in disarray, there was a parallel conference of C40 city mayors taking place in Copenhagen's town hall. The world mayors were gently competing over their success in meeting existing carbon reduction targets of 6 per cent, 8 per cent, or 10 per cent via two-year programmes. Their visioning was cultural, and their solutions were tailored to local ambitions and processes of delivery. Each of their citizens could imagine and take pride in their city's achievement; each collectively drove down their city's carbon emissions.

Cape Farewell was there as a guest of Mayor Miller of Toronto, the C40 cities president. He saw just how powerful a role the cultural sector could play by creating stories and film to provide vision for the cities' inhabitants. By motivating them, it became possible to accelerate the process of change. Then the failure of the UN conference cast a dark shadow over all climate discussions. The vested interest groups and political agendas resistant to change spread a fog of confusion across the conference and worldwide. Since then, atmospheric carbon levels have continued to rise, global habitats continue to be degraded, and food and water security issues threaten developing countries.

What next?

In 2012, Hurricane Sandy swept through New York, and the climate stories once thought to be apocryphal now have a human dimension. The seas have deluged great tracts of subways, and 40-storey business hubs have had their basements flooded to street level – not a catastrophe in itself, until you consider that all the computer equipment and power was housed underground, and the business machine has ground to a soggy halt. New York has provided individual stories of a global-scale event.

What we need now is human-scale solutions to global concepts. A two- or four-degree rise in global temperatures scares the hell out of the knowledgeable few, but remains without meaning to most. The numbers just seem to be empty figures, without the possibility of inspiring the imagination.

David Buckland and Amy Balkin, *Discounting the Future*, *Ice Texts* series (2010)

We have the means to fix the problem. Technological solutions for clean energy are sitting on the shelf, but need a trillion-dollar investment to make them productive. This is the scale of investment required to create a level playing field with the oil and coal industries, and make clean renewable energy cost-equivalent. Reaching for these new technologies requires an investment in, for example, DC cabling and 21st-century smart grid technology, which will unlock the creative design and 'liquid society' to establish a whole new economy – creating new employment, new social values and new economic models. Unlocking the desire for a sustainable future is probably more about imagination than reason; it is about the messy human condition that motivates change.

Legally, there is a 'golden bullet' which would solve the problem: a global price on carbon in the region of £200 per ton. If we adopted this, energy delivery would initially be less efficient, and it would be hard work to keep on track until equilibrium is re-established. This would also need a vast creative drive, to establish the nurturing and protection of our habitats – not just as an individual burden, but as the collective condition.

A two- or four-degree rise in global temperatures scares the hell out of the knowledgeable few, but remains without meaning to most. The numbers just seem to be empty figures.

We need both the thinking, and the feeling: to reframe public engagement, we need creative solutions in every sense. We need to win hearts and minds in order to achieve change.

Climate as culture

"... What if, on the basis of that,

The world as we know it changed its matter of fact...?"

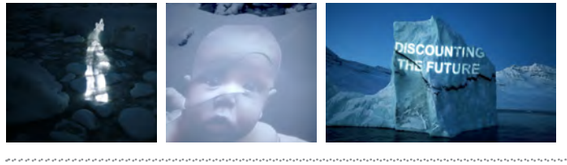
Lemn Sissay, poet

Can it be done? Unlikely by a single unilateral agreement for sure, but what if Europe, the USA and Brazil (plus other allies) declared a decree, binding in law? What if imported goods and raw materials were carbon-taxed to accommodate the cost of cleaning up the mess made in production?

Just imagine the cities of the 1840s: a mire of human waste and disease, until a few wise minds proposed ripping up the streets and substructures to put in place drainage and waste management at enormous cost. It took 10 years of human toil and citywide mess to eradicate typhoid and gastric disease, to remove the unimaginable smell and human excrement, to create tree-lined avenues and parks. We are in a similar place today. Carbon dioxide, methane, and other atmospheric pollutants are no less dangerous to humans than the diseases which have mostly been conquered in the 'developed' world. We need to clean up our act for the sake of our children.

The climate challenge is about human activity and civilisation. It is about framing climate as culture. According to Elizabeth Straughan of the Institute of Geography and Earth Sciences in Aberystwyth, "What... Cape Farewell... makes clear is that although the arts and humanities have much to say in regard to climate change, this is by no means a direct translation of climate science, nor is it the articulation of a warning with regard to human activity. Rather, this is a creative response that makes vivid a complex, often paradoxical, sensual and emotional engagement with environment. And this is precisely the terrain on which hearts and minds are won."

In this report, the Cambridge Programme for Sustainability Leadership has published a range of essays, each providing new vision, ideas and pragmatic solutions. Each underlines the urgent need for engagement and how we can achieve results with the tools and economic structures we already have in place. Each essay has allowed Cape Farewell to showcase an artist's work, bringing fresh thinking by realising something tangible: a photograph, sculpture, or story. It is clear that we need both the thinking, and the feeling: to reframe public engagement, we need creative solutions in every sense. We need to win hearts and minds in order to achieve change.



Left to right: David Buckland, *Pregnant Woman* (2008); David Buckland, *Baby on Ice* (2008); David Buckland and Amy Balkin, *Discounting the Future, Ice Texts* series, (2010).

In the work of Lucy + Jorge Orta, vitrines (glass cabinets or display cases) are focal points, drawing our attention to a specific subject or issue. Inside *Vitrine Amazonia* (2010), a photograph taken during the artists' Cape Farewell expedition to the Peruvian Amazon in 2009 is enlarged and fragmented. The pierced water gourds, containers, floats and glass bottles reference the artists' longstanding research focus on the subject of water.

Acknowledgements

Editor: Mike Peirce

Editorial assistance: Francesca Raphaely & Wayne Visser

Images generously provided by Cape Farewell www.capefarewell.com
Designed and produced by Fruit Design www.fruit-design.co.uk

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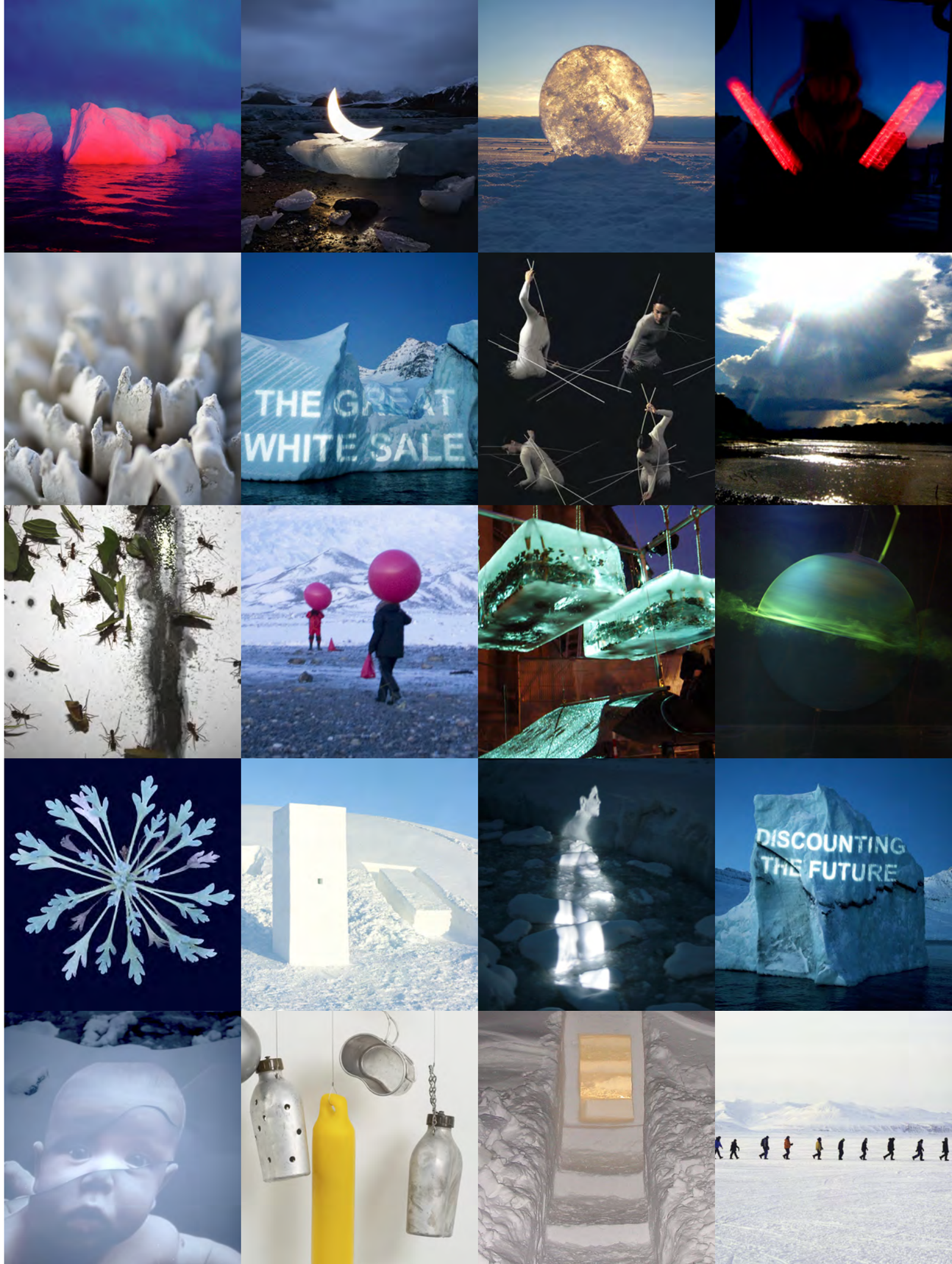

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CPSL contributes to the University of Cambridge's mission and leadership position in the field of sustainability via a mix of executive programmes and business platforms, informed by world-class thinking and research from the University and other partners. CPSL is an institution within the University's School of Technology. HRH The Prince of Wales is the patron of CPSL and we are a member of The Prince's Charities, a group of not-for-profit organisations of which His Royal Highness is President.

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This digital publication is designed and produced by Fruit Design
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